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Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps $= 2.22 \times 10^{12}$ dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces $= 2.205 \times 10^{-3}$ pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches = 3.28 feet
m^3	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
r/min	revolutions per minute	
s	second	
yr	year	

RADIATION DATA AND REPORTS

Volume 15, Number 3, March 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Department of Agriculture
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Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Russell E. Train, Administrator

Reports

Radiological Surveillance Around Turkey Point, 1970–1971

Wallace Johnson and Jearold Eakins[1]

Prior to the operation of the Turkey Point Nuclear Power reactor, environmental media were sampled and data are presented for 1970–1971. Basic media investigated include air, precipitation, soil, silt, and water, including sea water.

A number of media utilized as indicator organisms serve to investigate the behavior of radionuclides in several ecological levels. Indicators are mangrove vegetation, fresh water algae, turtle grass and sponges. Additional items found in the human food chain that were analyzed include crustacea, fish, and food crops.

The Florida Division of Health has conducted radiological surveillance around the Turkey Point site of Florida Power and Light Company since August 1969. Sampling is conducted by the Radiological and Occupational Health Section.

Turkey Point Nuclear Units 3 and 4 are located on the western shore of Biscayne Bay about 25 miles south of Miami, Florida. The site consists of 3300 acres of which the plant, including two operating fossil-fueled units, occupies about 150 acres of compacted limestone fill. East of the site, 5 to 8 miles across Biscayne Bay, is a series of islands running in a northeast-southwest direction between the bay and the Atlantic Ocean.

To the north and west of the site, land use is primarily agricultural to a distance of about 7 miles where urban development begins, becoming densely populated further north along the coast.

The southern coastland consists of uninhabited mangrove swampland extending inland from 1 to 3 miles. Dade County's Homestead Bayfront Park begins immediately north of the plant site and a Hawk Missile Base adjoins the site near the northwest corner.

Samples are obtained from the sampling locations shown in figures 1 and 2. The samples are analyzed in the Radiological Laboratory of the Division of Health in Orlando. Gamma analysis data were obtained using 10 cm $\times$ 10 cm NaI detectors based on a 9 $\times$ 9 matrix resolution of spectra calculated by the simultaneous equation method. Beta determinations are made using a Sharp Lo Beta counting system or a Nuclear Chicago low background proportional counter, model 4334. Low energy beta samples are counted on a Packard Tri-Carb Liquid Scintillation Spectrometer, Model 3375.

An internal quality control program is conducted to define the precision of analyses. Twenty percent of the samples are divided and analyzed in two parts. These samples are not identified to laboratory personnel until the end of the quarter. This parameter defines the analytical variability between sample analyses.

For example, based on this parameter, the following differences in samples would be required to define a significant difference.

[1] Radiological and Occupational Health Section, Bureau of Preventable Diseases, Division of Health, Department of Health and Rehabilitative Services, Jacksonville, Fla. 32201.

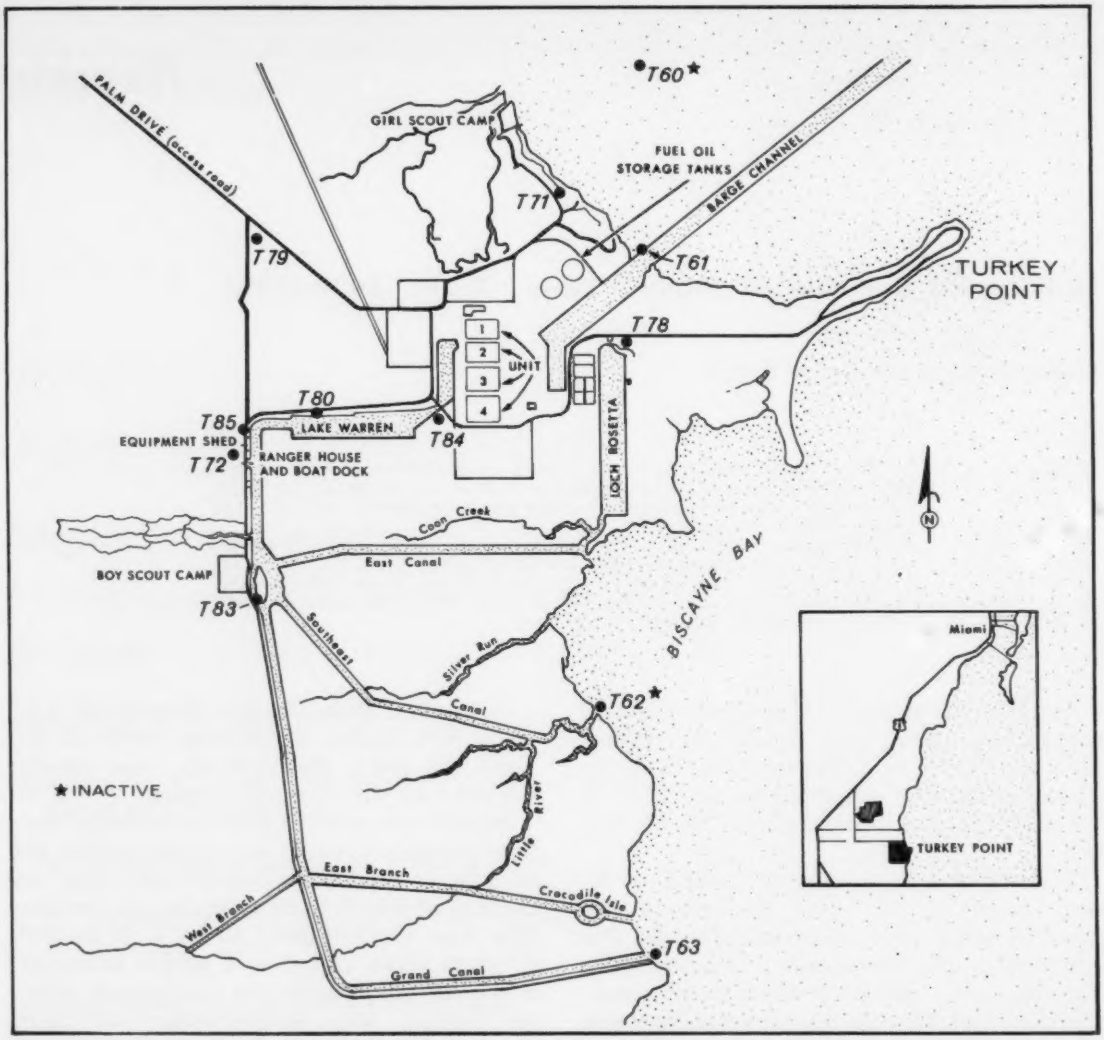

Figure 1. Onsite sampling locations, Turkey Point plant area

Silt and soil samples (see table 1)

Gamma analysis	Significant difference
Cerium–144	358 pCi/kg wet weight
Ruthenium–106	223 pCi/kg wet weight
Cesium–137	148 pCi/kg wet weight
Zirconium–95	108 pCi/kg wet weight
Gross beta (including	3.1 pCi/g ash
potassium–40)	1 822 pCi/kg wet weight

The parameter, however, is defined only for those radionuclides which have been consistently present in quantities greater than the practical reporting limit.

External quality control to estimate the accuracy of analyses has been conducted using split samples and interlaboratory comparisons. A summary of 1971 quality control results are shown in table 2.

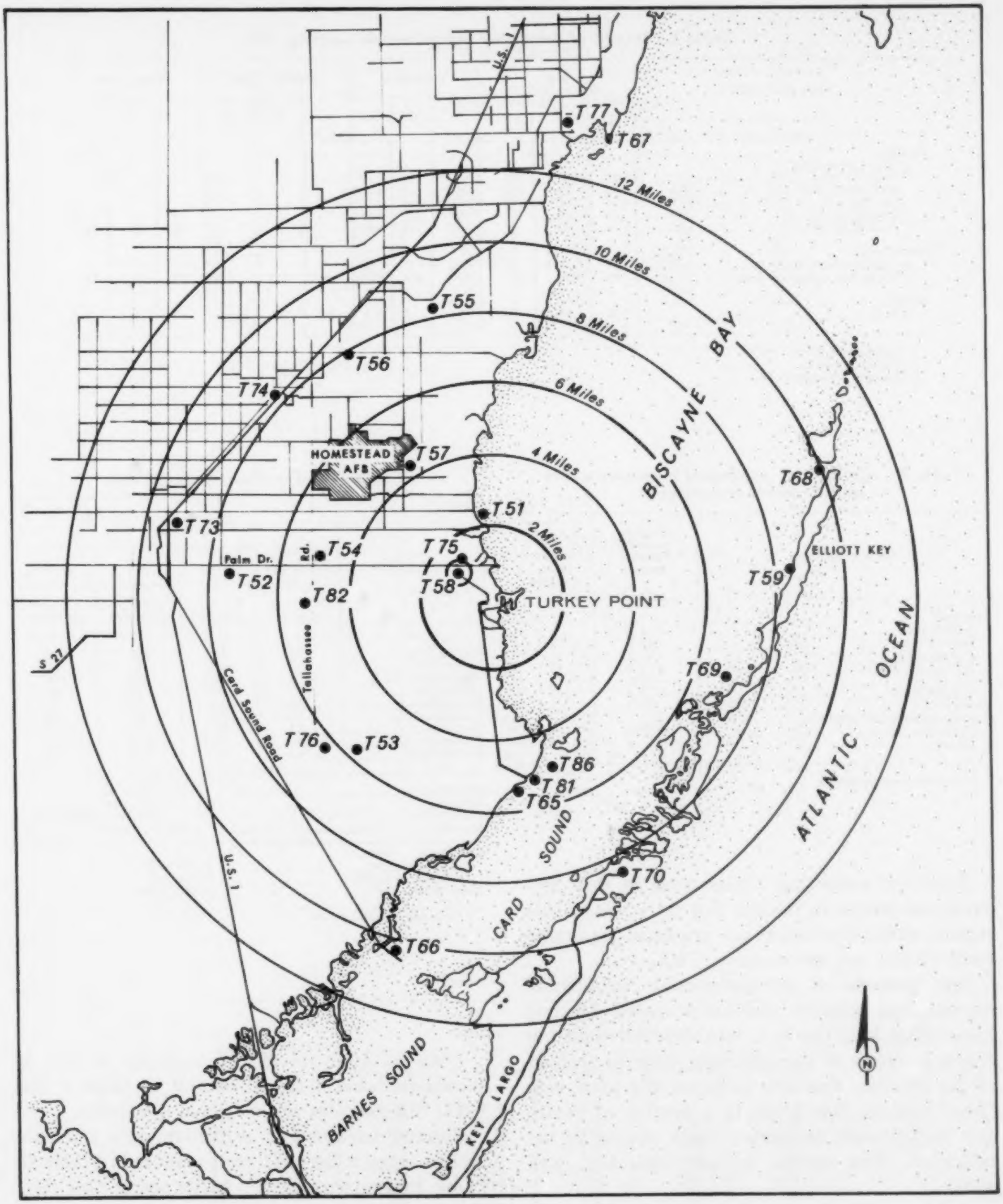

Figure 2. Offsite sampling survey stations, Turkey Point

Table 1. Results of the quality control sample analysis, 1971

Type of analysis	Soil			Vegetation			Water, UDS[a]			Water, DS[b]		
	n	$\overline{X}$	σ	n	$\overline{X}$	σ	n	$\overline{X}$	σ	n	$\overline{X}$	σ
Gamma:												
(pCi/g wet weight)												
Cerium–144	28	166	192									
Ruthenium–106	11	94	129	15	148	105						
Cesium–137	21	71	77	28	108	167						
Zirconium–95	21	48	60	27	117	134						
Potassium–40	6	35	47	38	452	492				29	43	30
Gross beta: [c]												
(pCi/g wet weight)	36	1.5	1.6	38	17	16						
(pCi/kg wet weight or liter)	36	885	937	38	354	388	42	0.7	2.9	42	48	62
Weight:												
(g wet)	36	27	30	38	2	2	42	74	416	42	0.5	0.6

[a] Undissolved solids.
[b] Dissolved solids.
[c] Includes potassium–40.

Table 2. Summary of radiological laboratory's 1971 quality control cross-checks

Type of analysis	Average percent relative error	Number of cross-check samples
Gamma:		
Iodine–131	+11.2	6
Barium–140	+12.9	1
Cesium–137	− 7.7	10
Ruthenium–106	+ 4.2	1
Cobalt–60	− 4.2	2
Potassium–40	+ 2.9	7
Gross beta [a]	−31.3	3
Specific radionuclide analysis:		
Strontium–90	+ 8.0	10
Tritium	− .3	3

[a] Includes potassium–40.

Practical reporting limits used in this program are shown in table 3. For purposes of this report, activities below the practical reporting limit (PRL) are shown as < PRL.

One purpose of preoperational radiological surveillance around nuclear-powered electric generating facilities is to establish the radiation characteristics of the environs prior to startup of the reactor. For this purpose, the preoperational radionuclide levels in a number of media and background radiation levels should be established. The media include soil, silt, and water.

Data on soil analyses for commonly detected nuclides are shown in table 4 for 1970 and in table 5 for 1971. Soil samples are collected semiannually.

Table 3. Practical reporting limits

Radionuclide	Concentration (pCi/liter)			
	Vegetation	Water	Soil	Biota
	3.5 liter geometry	3.5 liter geometry	1.0 liter geometry	1.0 liter geometry
Cerium–144	97	97	200	200
Iodine–131	17	17	40	40
Ruthenium–106	83	83	180	180
Cesium–137	17	17	40	40
Zirconium–95	14	14	30	30
Manganese–54	14	14	30	30
Zinc–65	31	31	70	70
Potassium–40	180	51	390	390
Barium–140	17	17	40	40
Strontium–90	0.08 pCi/g ash			
Tritium	200 pCi/liter			
Cobalt–60	40 pCi/liter (separation)			
Iron–55	0.125 pCi/g ash			
Gross beta[a] — water:				
Dissolved solids	3 pCi/liter			
Undissolved solids	3 pCi/liter			
Gross beta[a] — ash	10 pCi/g ash			

[a] Includes potassium–40.

Data on analysis of radioactivity in silt is shown in table 6 for 1970 and in table 7 for 1971. Silt samples are collected quarterly.

Gamma background radiation data normalized to μrem/h for 1971 are presented in table 8. These measurements are made using CaF:Mn glass envelope thermoluminescent dosimeters (Victoreen Model 2600–17) with readout on a Victoreen Model 2600 B thermoluminescent dosimeter reader. The dosimeters are calibrated

Table 4. Soil, 1970

Sampling location	Radionuclide (annual average pCi/kg wet weight)				
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Cesium-137
T51	<?90	1 062	<291	<155	522
T52	<390	<685	<220	<72	492
T53	<390	[a] 3 200	[a] 1 500	[a] 490	[a] 950
T54	<390	632	<180	<57	180
T55	<390	830	<180	<50	347
T56	<390	<812	<180	<37	320
T57	<390	910	<275	<132	305
T58	<390	912	<327	<205	100
T59	<390	<543	<247	87	285
T72	<497	<467	<180	<33	<63
Grand mean	<401	<1 005	<358	<132	<356
Control:					
T64	<390	447	<267	<95	<55

[a] Only one observation.

Table 5. Soil, 1971

Sampling location	Radionuclide (annual average pCi/kg wet weight)					
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]	Cesium-137
T51	<390	<575	<290	<200	—	<170
T52	<390	575	<185	80	—	475
T53	<395	2 100	1 025	440	11 000	570
T54	<565	910	<180	<100	—	475
T55	<390	<525	<180	<70	—	395
T56	<945	<200	<180	<90	14 000	<170
T57	<390	<415	<180	<60	—	315
T58	<390	<850	<585	<365	—	<85
T59	<390	[b] 740	[b] 350	[b] 120	—	[b] 360
T72	<390	<205	<180	<55	—	<40
Grand mean	<464	<710	<334	<158	12 500	<254
Control:						
T64	<412	<562	<245	<140	—	<355

[a] Includes potassium-40.
[b] Only one observation.

Table 6. Silt, 1970

Sampling location	Radionuclide (annual average pCi/kg wet weight)				
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Cesium-137
T51	<390	<310	<180	<37	<40
T60	<555	<490	<180	<30	<40
T61	<390	<400	<180	<30	<40
T63	<503	767	<183	<53	<60
T64	NA	NA	NA	NA	NA
T65	<390	<305	<180	<30	<40
T66	<390	<235	<180	<30	<40
T71	<407	<550	<180	87	<40
T72	<407	<220	<180	<30	<40
T75	<417	380	<180	70	<40
T76	<390	<312	<180	<30	<122
Grand mean	<424	<397	<180	<43	<50

NA, no analyses.

Table 7. Silt, 1971

Sampling location	Radionuclide (annual average pCi/kg wet weight)					
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]	Cesium-137
T51	<390	487	<257	<150	2 100	<40
T60	487	580	<180	<30	2 680	<42
T61	500	<487	<180	<37	3 050	<40
T63	<472	<437	<180	<35	3 150	<40
T65	<390	<322	<180	<30	ND	<40
T66	<472	355	<180	<32	ND	<40
T71	<390	587	<180	<33	ND	<40
T72	<402	<200	<180	<30	ND	<40
T75	<390	<452	<200	<70	2 900	<40
T76	<390	898	<294	<130	7 370	<174
T80	<390	630	<215	<85	[b] 2 600	<40
T83	<390	<367	<183	100	[b] 2 000	<40
Grand mean	<422	<484	<201	<64	<3 230	<51
Control:						
T64	<390	<233	<180	<40	ND	<40

[a] Includes potassium-40.
[b] One observation. Other three nondetectable.
ND, nondetectable.

Table 8. Gamma background levels, 1971

Sampling location	Dose rate (μrem/h)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
T51	NA	NA	NA	NA	NA	NA	NA	20	20	18	13	18	18
T52	17	17	19	21	19	18	18	18	18	20	18	20	19
T56	18	NA	20	22	20	20	19	21	19	18	15	19	19
T57	17	17	19	20	19	19	18	18	18	20	14	17	18
T58	22	17	21	20	20	18	19	18	19	20	18	21	19
T64	14	19	17	20	18	20	16	19	NA	19	17	19	18
T70	NA	14	20	15	21	15	16	21	20	17	16	20	18
T71	15	17	16	18	16	17	15	17	16	18	17	18	17
T72	16	16	18	18	18	16	17	16	17	16	18	17	17
T78	NA	17	18	18	17	17	16	17	17	17	16	17	17
T79	NA	19	15	20	14	18	13	18	15	17	15	17	16
Mean	17	17	18	19	18	18	17	18	18	18	16	18	

NA, no analysis.

against a cobalt-60 source using a Victoreen R chamber as a secondary standard. Since the objective of this sampling is to establish baseline values from which to measure changes, no attempt has been made to determine absolute environmental backgrounds. Correction has not been made for the inherent drift of the dosimeter; hence, the values reported are for gross dosimeter response. The mean values of reported dosimeter drift have been determined to range from 6.78 μrem/h to 10.79 μrem/h with an average value of 8 μrem/h.

The standard deviation of measurements within monthly groups can be calculated to be 2 μrem/h while the standard deviation between monthly groups can be calculated to be 3 μrem/h. Based on these values, a change of $x \pm 4$ μrem/h between stations or $x \pm 6$ μrem/h between months would be significant at the 95 percent confidence level. A two-way analysis of variance performed on the data indicates that differences in means of monthly observations are significant at the 95-percent confidence level.

Monthly values for 1970 dosimeters are listed in table 9. Sites T70, T78, and T79 were not equipped with TLD's until February 1971. Site T51 was started in August 1971.

Table 9. Gamma background levels, 1970

Sampling location	Dose rate (μrem/h)				
	Aug	Sept	Oct	Nov	Dec
T52	15	14	13	15	15
T56	16	15	15	15	18
T58	14	12	13	12	15
T64	15	13	14	14	16
T71	14	12	13	13	15
T57	15	13	14	15	16
T72	13	14	12	14	12
Mean	15	13	13	14	15

continuously. Particulates are collected on 2-inch vinyl metricel filters (Gelman VM-1). The filters are collected biweekly and analyzed for gross beta. During this reporting period, all results have been less than 1 pCi/m^3. This value is used as the practical reporting level in this laboratory.

Monthly composites of these filters have been analyzed by gamma spectroscopy and results for 1970 are shown in table 10. No gamma results are available for 1971.

Table 10. Turkey Point gamma scan particulates in air, 1970[a]

Radionuclide	January (pCi/sample)	February (pCi/sample)	March (pCi/sample)	April (pCi/sample)	May (pCi/sample)	June (pCi/sample)
Cerium-praseodymium-144	ND	ND	ND	310	290	390
Iodine-131	ND	ND	ND	ND	ND	ND
Ruthenium-rhodium-106	ND	ND	ND	ND	ND	ND
Cesium-137	ND	ND	ND	ND	ND	ND
Zirconium-niobium-95	ND	ND	ND	50	60	100
Manganese-54	ND	ND	ND	ND	ND	ND
Zinc-65	ND	ND	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND	ND	ND
Barium-lanthanum-140	ND	ND	ND	ND	ND	ND
Sample volume (m^3)	2 630	3 543	6 472	5 713	4 775	7 266
	July (pCi/sample)	August (pCi/sample)	September (pCi/sample)	October (pCi/sample)	November (pCi/sample)	December (pCi/sample)
Cerium-praseodymium-144	260	ND	ND	ND	290	230
Iodine-131	ND	ND	ND	ND	ND	ND
Ruthenium-rhodium-106	ND	ND	ND	ND	280	470
Cesium-137	ND	ND	ND	ND	ND	ND
Zirconium-niobium-95	50	30	30	30	100	110
Manganese-54	ND	ND	ND	ND	ND	ND
Zinc-65	ND	ND	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND	ND	ND
Barium-lanthanum-140	ND	ND	ND	ND	ND	ND
Sample volume (m^3)	5 046	3 187	3 798	6 099	6 184	6 879

[a] All site samples composited by month of collection and dissolved in 1.0 liter of nitric acid. Detectable levels are: cerium-praseodymium-144 200 pCi; iodine-131, 40 pCi; ruthenium-rhodium-106, 180 pCi; cesium-137, 40 pCi; zirconium-nobium-95, 30 pCi; manganese-54, 30 pCi; zinc-65, 70 pCi; potassium-40, 180 pCi; and barium-lanthanum-140, 40 pCi.
ND, nondetectable.

Table 11. Analysis of seawater, 1971

Sampling location	Annual average concentration (pCi/liter)				
	Potassium-40	Cobalt-58	Cobalt-60	Tritium	Gross beta[a]
T51	327	<40	<40	<200	438
T60	344	<40	<40	<200	448
T61	348	<40	<40	<200	461
T63	347	<40	<40	<200	459
T65	347	<40	<40	<200	430
T66	393	<40	<40	<200	524
T67	376	<40	<40	<200	427
T71	340	<40	<40	<200	508
T72	356	<40	<40	<200	481
Mean	353	<40	<40	<200	464

[a] Includes potassium-40.

Sampling for particulates in air is conducted using a low-volume (1 cfm) sampler operated

Analysis of seawater and of precipitation are shown in tables 11 and 12. Results of well water analyses are not shown since all results have been less than the practical reporting limits. Seawater collection frequency is monthly. Precipitation is also collected monthly, but actual quantity collected depends on monthly rainfall. In order to obtain a sample, at least 3.5 liters must have been collected in the sampler during the previous month.

The foregoing data represent the basic environmental media and serve to demonstrate radionuclides present in detectable amounts.

The remainder of the data serves to investigate the behavior of these radionuclides in several ecological levels. The first such groups

Table 12. Analysis of precipitation, 1971

Sampling location	Radionuclide concentration (pCi/liter)			
	Cobalt-58	Cobalt-60	Tritium	Gross beta [a]
T64	<40	<40	<200	11
T79	<40	<40	<200	8

[a] Includes potassium-40.

include a number of media utilized as indicator organisms. These items may, or may not, be a part of a food chain pathway. One such indicator is the mangrove (*Rhizophora* mangle). Mangroves are one of the most important elements in the ecology of tropical and subtropical areas. Energy flow, or the movement of nutrients from the land to the estuary, is the basic key to many of the lower food webs, since decomposition of the organic matter produced by the mangrove results in great quantities of food for plant and animal plankton.[2]

Analysis of mangrove vegetation (leaves) for 1970 is shown in table 13 and for 1971 in table 14. Mangrove samples are collected on a quarterly basis.

The fresh water alga, *Chara,* was chosen as another indicator of radionuclide reconcentration. *Chara* is found usually in alkaline or hard water streams where calcium is abundant in the form of carbonates or bicarbonates. Marl and other kinds of calcareous deposits may be formed largely by *Chara* over long periods of time (*1*).

[2] Draft detailed statement for Turkey Point, Units 3 and 4, by the Division of Radiological and Environmental Protection, U.S. Atomic Energy Commission, February 1972.

Table 13. Mangrove vegetation, 1970

Sampling location	Annual average concentration (pCi/kg wet weight)				
	Potassium–40	Cerium–144	Ruthenium–106	Zirconium–95	Cesium-137
T51	3 080	<285	<478	345	< 55
T53	2 150	<240	<280	140	105
T58	2 580	<259	<333	<240	< 43
T59	5 930	<200	<338	233	<136
T64	2 700	<290	<457	307	< 45
Mean	3 290	255	376	253	77

Polikarpov (*2*) reports the mean concentration factor of 20 radionuclides in *Chara* to be 2 630. These radionuclides include zirconium–95, ruthenium–106, and cerium–144, which are among isotopes seen in our *Chara* samples.

Table 15 lists the *Chara* samples analyzed in 1970 and 1971 along with water samples taken at the same location. This could serve to demonstrate concentration factors, but all water samples showed less than PRL values. It should be realized that the concentration factor given by Polikarpov is in relation to dry weight, whereas our results are reported by kilogram of wet weight. *Chara* samples are collected on a quarterly basis.

Turtle grass (*Thalassia testudinum*) and *Sargassum* were chosen as representative marine algae because of their abundance in shallow bays of South Florida.

Turtle grass is of tremendous importance as a habitat and nursery ground for marine animals. It also furnishes food for many creatures and helps stabilize bay bottoms by holding the sediments in place. Based on samplings done by the Miami Institute of Marine Sciences,

Table 14. Mangrove vegetation, 1971

Sampling location	Annual average concentration (pCi/kg wet weight)					
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]	Cesium-137
T51	3 250	<200	<310	<200	3 150	<40
T53	1 600	<200	<382	172	2 480	<40
T58	3 350	<200	<347	195	3 720	<62
T59	3 280	<200	523	270	3 900	<73
Mean	3 670	<200	<390	<209	3 310	<54
Control: T64	[b] 2 800	<200	[b] 270	[b] 170	[b] 3 200	[b] <40

[a] Includes potassium–40.
[b] One observation.

Table 15. Fresh water algae (*Chara*) and water samples, annual average means of detectable observations from Location T54

Radionuclide	1970		1971	
	Chara (pCi/kg wet weight)	Water (pCi/liter)	Chara (pCi/kg wet weight)	Water (pCi/liter)
Potassium–40	3 230	<51	<617	<51
Cerium–144	240	<97	<340	<97
Ruthenium–106	<180	<83	<280	<83
Zirconium–95	80	<14	<157	<14
Gross beta [a]		9	1 900	16

[a] Includes potassium–40.

Table 16. Turtle grass, 1971

Sampling location	Annual average concentration (pCi/kg wet weight)				
	Potassium–40	Cerium–144	Ruthenium–106	Zirconium–95	Gross beta [a]
T63	2 900	<340	<745	585	3 550
T66	4 770	<340	<290	227	4 800
Mean	3 830	<340	<517	406	4 170

[a] Includes potassium–40.

Table 17. *Sargassum*, 1971

Sampling locations	Annual average concentration (pCi/kg wet weight)				
	Potassium–40	Cerium–144	Ruthenium–106	Zirconium–95	Gross beta [a]
T51	6 180	<340	<290	380	6 080
T65	7 400	<340	<290	590	9 800
Mean	6 790	<340	<290	485	7 940

[a] Includes potassium–40.

it is estimated that 1-square mile of turtle grass will contain about 235 million shrimp and 95 billion mollusks. These animals serve as food for larger animals (*3*).

Sargassum is also an important plant, for it has its own ecological system. It provides shelter for many pelagic creatures, some of whom spend their entire life concealed in the seaweed. The particular species which we collect is floating and is never found attached (*3*).

Tables 16 and 17 give the results of radionuclide analysis on turtle grass and *Sargassum*, respectively. The only significant difference noted is the higher potassium–40 levels in *Sargassum*. Turtle grass and *Sargassum* are collected quarterly.

Sponges are perhaps the best indicator organism collected in the Turkey Point area. They consistently show higher levels of radionuclides than do other forms of marine life. This concentration is probably due to the fact that they are filter feeders and constantly draw water through their bodies, straining out minute organisms. Sponges are also easily collected. They are sessile benthic animals and thus do not migrate as do fishes and other marine organisms.

Table 18 lists the various radionuclides found in sponges collected and analyzed during 1970 and 1971. Sponge samples are collected quarterly.

Table 18. Sponge analysis, 1970–1971

Sampling location	Concentration (pCi/kg wet weight)					
	^{144}Ce	^{106}Ru	^{137}Cs	^{95}Zr	^{40}K	Gross beta [a]
1970						
T59	3 500	1 200	<40	560	2 500	7 210
T63	1 200	1 000	<40	300	1 400	4 080
T68	2 200	1 300	<40	660	1 700	7 770
T69	1 500	1 700	<40	760	<390	10 200
	2 700	2 300	<40	610	1 600	5 950
Mean	2 200	1 500	<40	578	<1 520	7 030
1971						
T68	1 800	700	<40	200	1 800	8 170
	7 400	<180	<40	90	1 800	15 200
Mean	4 600	<440	<40	145	1 800	11 700

[a] Includes potassium–40.

The remaining analyses constitute items found in the human food chain. Tables 19 and 20 give data for crustacea collected during 1970 and 1971. The most commonly sampled in

Table 19. Crustacea analysis, 1970 [a]

Sampling location	Type	Concentration (pCi/kg wet weight)				
		^{137}Cs	^{106}Ru	^{95}Zr	^{40}K	Gross beta [b]
T53	Blue crab	160	<180	<30	2 400	2 720
T54	Crayfish	110	200	50	2 400	1 440
T75	Lobster	150	<180	<30	1 500	1 480
Mean		140	<187	<37	2 100	1 880

[a] Entire organism is analysed.
[b] Includes potassium–40.

Table 20. Crustacea analysis, 1971[a]

Sampling location	Type	Concentration (pCi/kg wet weight)				
		^{137}Cs	^{106}Ru	^{95}Zr	^{40}K	Gross beta[b]
T61	Blue crab	<40	<180	<30	1 300	2 340
T65	Land crab	160	<180	<30	1 600	[c]5 110
T66	Blue crab	<40	<180	<30	1 200	2 430
	Blue crab	<40	<180	<30	1 400	3 080
Mean		<70	<180	<30	1 380	3 240

[a] Entire organism is analyzed.
[b] Includes potassium-40.
[c] One detectable observation.

this group is the blue crab, *Callinectes sapidus*. Blue crabs are harvested commercially in the Biscayne Bay-Card Sound area. When available, crustacea are collected quarterly.

Tables 21 and 22 are analyses of fish collected at Turkey Point for the 2-year period. These fish are listed by common name except for those listed as unclassified. The unclassified samples were composed of more than one species of fish, usually a mixture of pinfish, small jacks and barracudas.

Food crop analysis for 1970 and 1971 is compiled in table 23. Five locations are sampled on a monthly basis. These locations cover the principal farming areas in the northwest quadrant between 4 and 8 miles. However, due to climatic conditions, truck farming is practiced principally in the winter months, thus making sample collection difficult in the summer. In addition, crop rotation is practiced at most sites so that collection of a single crop at each site on every sampling is impossible. Sampling techniques involve collection of only the edible portions of the food crops at or about harvest time.

Table 21. Fish analysis, 1970[a]

Sampling location	Type	Concentration (pCi/kg wet weight)			
		^{137}Cs	^{40}K	Gross beta[b]	^{90}Sr
T53	Unclassified	260	1 800	2 320	159
T60	Barracuda	<40	3 700	1 420	NA
	Barracuda	<40	3 000	1 950	NA
T61	Jack	<40	2 800	1 680	NA
	Mangrove snapper	<40	2 800	1 760	NA
T62	Unclassified	50	2 700	1 570	NA
	Unclassified	50	3 200	1 720	5
	Unclassified	60	3 300	2 450	5
	Tarpon	<40	2 000	1 220	NA
	Jack	<40	2 800	1 900	NA
T63	Unclassified	50	2 500	2 340	15
	Mangrove snapper	<40	2 900	1 600	NA
	Weakfish	<40	2 400	1 620	NA
	Jack	<40	3 300	2 320	NA
T65	Unclassified	60	3 400	1 780	26
	Jack	40	1 800	2 010	NA
T66	Unclassified	60	3 000	2 480	26
	Unclassified	50	2 500	3 190	24
	Mullet	50	2 600	2 310	17
	Mullet	<40	1 800	1 870	NA
T68	Unclassified	<40	2 600	2 350	NA
T69	Unclassified	<40	2 700	2 690	NA
T75	Unclassified	240	1 400	1 820	88
T76	Unclassified	110	2 600	1 610	NA
	Unclassified	420	1 700	2 390	245
	Gar	290	1 600	1 720	NA
	Tarpon	100	1 300	982	NA
Mean		<88	2 500	1 970	61

[a] Entire organism is analyzed.
[b] Includes potassium-40.
NA, no analysis.

Table 22. Fish analysis, 1971[a]

Sampling location	Type	Concentration (pCi/kg wet weight)			
		^{137}Cs	^{40}K	Gross beta[b]	^{90}Sr
T62	Mangrove snapper	50	2 600	2 890	NA
	Mangrove snapper	<40	2 600	2 470	479
	Barracuda	<40	2 800	4 910	NA
	Unclassified	<40	3 600	4 370	NA
T63	Barracuda	<40	3 200	3 680	2.5
	Barracuda	100	2 300	3 480	NA
	Barracuda	<40	2 400	3 720	NA
	Barracuda	<40	2 500	4 600	NA
T65	Unclassified	70	2 500	2 040	3
	Snook	40	700	1 700	NA
	Jack	60	2 900	2 620	NA
T66	Mullet	<40	1 800	3 930	10.6
	Mullet	<40	1 500	4 000	NA
	Mullet	<40	1 800	3 050	21.8
	Mullet	40	2 500	3 210	NA
T68	Unclassified	<40	2 700	2 140	1
	Pin fish	<40	2 300	3 380	NA
T69	Unclassified	<40	2 600	2 000	18
	Unclassified	<40	2 300	4 380	NA
	Unclassified	<40	2 400	2 280	NA
Mean		<46	2 400	3 240	76.6

[a] Entire organism is analyzed.
[b] Includes potassium-40.
NA, no analysis.

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(*2*) POLIKARPOV, G. G. Radioecology of aquatic organisms (English translation). Reinhold Book Division, New York, N.Y. (1966).

(*3*) STEPHENS, W. M. Southern seashores. Holiday House, New York, N.Y. (1968).

Table 23. Analysis of food crops, 1970–1971

Sampling location	Food crop	Concentration (pCi/kg wet weight)		
		^{40}K	Gross beta [a]	^{90}Sr
1970:				
T52	Collard greens:	3 100	1 010	55
		3 200	2 020	53
		3 500	2 430	46
		2 800	836	20
		3 200	2 670	36
		4 100	2 450	58
		4 700	1 880	
	Mean	3 510	1 900	45
T54	White potatoes:	4 100	2 340	2
		3 800	2 800	4
		4 500	2 980	3
		4 000	2 830	5
	Mean	4 100	2 740	3.5
T55	Sweet potatoes:	2 600	2 460	12
		3 500	2 470	NA
		2 700	1 820	14
		1 900	765	NA
	Mean	2 680	1 880	13
	White potatoes:	4 000	3 090	3
		4 000	3 610	2
		4 300	3 300	3
	Mean	4 100	3 330	2.7
T56	Tomatoes:	2 500	1 690	3
		2 300	1 210	3
	Squash:	2 300	1 410	8
	Papaya:	2 500	2 060	8
	Sorghum:	3 100	4 110	40
	Guava:	2 000	937	NA
	Sweet potatoes:	2 500	1 130	NA
	Corn:	1 900	1 100	NA
T57	White potatoes:	3 700	4 320	[b] 42
		4 100	3 040	1
		3 800	2 010	1
		4 400	2 050	4
		4 600	2 880	6
	Mean	4 120	2 860	3.0
1971:				
T52	Collard greens:	3 500	1 300	84
		4 100	3 300	
		3 000	2 900	46
		3 400	3 100	5
	Mean	3 500	2 650	45
	Corn:	2 200	2 000	NA
	Okra:	3 600	3 600	35
T54	Collard greens:	3 900	4 200	NA
	Cabbage:	2 600	2 200	NA
	White potatoes:	3 400	3 200	4
	Corn:	2 400	2 100	NA
T55	Corn:	1 800	980	<1
		1 600	1 200	NA
		2 000	2 200	NA
	Mean	1 800	1 460	<1
	White potatoes:	3 500	3 000	2
		4 200	3 600	NA
	Tomatoes:	3 000	1 100	NA
T56	Corn:	1 900	1 000	<1
		1 800	1 300	NA
		2 300	1 800	NA
		2 500	2 400	NA
		2 600	2 500	NA
	Mean	2 220	1 800	<1
	White potatoes:	3 600	3 900	3
		3 500	3 400	NA
	Squash:	2 200	1 200	NA
	Beets:	2 900	2 180	NA
T57	Cabbage:	4 600	1 500	30
		3 800	3 100	NA
		2 200	1 900	NA
	Mean	3 530	2 170	30
	White potatoes:	3 800	3 300	NA
	Green beans:	5 600	3 300	NA
	Sorghum:	3 000	3 100	NA

[a] Includes potassium-40.
[b] Stranger, not used in calculation of mean.
NA, no analysis.

Preoperational Levels of Environmental Radioactivity in Water and Sediment Around Turkey Point Nuclear Power Plants, Card Sound, Florida

Tod S. Johnson and Thomas D. Pemble[1]

An investigation of the levels and distribution of gross alpha, gross beta and selected gamma-emitting radioisotopes present in water and sediment samples from Card Sound, Fla. was performed. This environmental radioactivity baseline study, was carried out between January 1971 and June 1972, prior to operation of the Turkey Point Nuclear Power Plants and discharge of liquid effluents from these plants into Card Sound.

This report describes the levels of radioactivity in seawater and sediment samples from Card Sound, a small bay approximately 5 miles long and 3 miles wide, located on the southeast coast of Florida (figure 1). This area was studied because Florida Power and Light Co. (FPL) was constructing a 6-mile long canal for use in cooling effluent water from two nuclear power plants under construction at Turkey Point and planned to discharge the effluent water from the canal into Card Sound.

The radionuclide data reported in this paper were obtained in collaboration with investigators at the University of Miami Rosenstiel School of Marine and Atmospheric Sciences.[2] During the reporting period (January 1971 to June 1972) many of the same sample stations and sample periods were used cooperatively for collection of samples and extensive work (i.e. chemical, biological and physical studies) has been carried out by other investigators,[3] thereby allowing cross-correlation of data.

Sample collection and analysis

Card Sound water and sediment samples were collected at various times between January 1971 and June 1972, i.e. prior to operation of the Florida Power and Light nuclear power plants at Turkey Point. Initially, surface and bottom water samples were collected at each station using 1 liter polyethylene bottles. The last four sample periods were limited to a single "representative" sample from each station (either top or bottom). Bottom water samples were obtained using a modified Niskin bottle, while surface samples were taken by hand. The coded bottles were then brought to the laboratory, chilled in a refrigerator, and 1-liter aliquots from each sample transferred to plastic bags (#0.003),[4] heat sealed with a

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[2] Collaborating investigators: Douglas Segar, Ph.D. and Sol Gerchakov, Ph.D., Chemical Oceanography Department, and Mr. Kenneth O. Barry, Computer Services, Rosensteil School of Marine and Atmospheric Sciences.

[3] The overall collaborative program was entitled "An Ecological Study of South Biscayne Bay and Card Sound, Florida" (Dr. Richard G. Bader and Dr. Martin A. Roessler, principal investigators). The work covered in the present report was sponsored by a grant from the U.S. Atomic Energy Commission (AT–(401)–3801) and the Florida Power and Light Co.

[4] Seal-Tite Plastic Packaging Co., P.O. Box 66, Perrine, Fla. 33157.

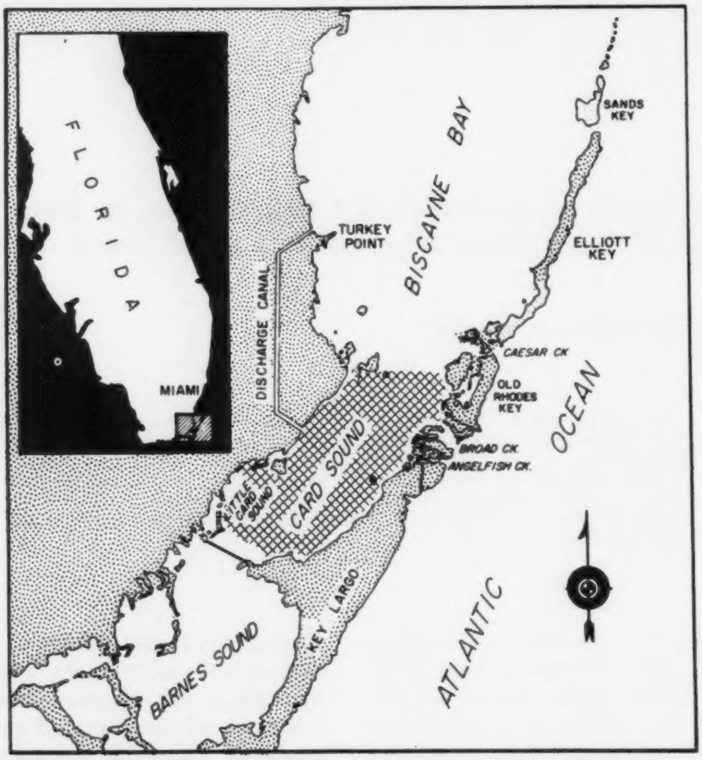

Figure 1. Geographical location of the Card Sound study area in relation to FPL Turkey Point discharge canal

Thermal-Impulse Sealer and placed in cylindrical (7 × 14.6 cm) containers for counting.

The gamma counting system consisted of a heavily shielded counting chamber (6-inch steel walls with 1/8 inch lead and several layers of 1/8 inch tin) housing two matched 4 by 8-inch Harshaw NaI(Tl) crystals, each with three photomultiplier tubes and a mixer. The signals from the mixers feed to an anticoincidence unit, then to a preamplifier and a Nuclear Data Model 180, multi-channel analyzer. Data acquisition and storage was achieved by use of a Cypher Model 7H magnetic tape unit. The analyzer system was calibrated at 5 keV/channel using a combination disc source of cesium–137 and cobalt–60, with routine background, linearity and zero shift checks made several times a week.

Following gamma counting, each 1 liter sample was suction filtered[5] using a Buchner funnel with 9-cm diameter No. 40 Whatman filter paper disc and the suspended solids fraction prepared for planchet[6] counting following the method previously described by Porter et al. (*1*). The dissolved solids fraction of filtered seawater was evaporated overnight using a heated mineral oil bath, air dried, and weighed; then 1 g planchet samples were prepared using the method of Porter et al. (*1*). The gross alpha and gross beta activities were then determined using a Nuclear-Chicago Model 1152 low-background, gas proportional counter.

[5] Although carbonate precipitation with chemical fractionation is a more sensitive determination of salt water alpha and beta activities, the simple, widely-used filtration-evaporation method was adequate for the baseline reactor preoperation study.

[6] Nuclear-Chicago Model 3310 2-inch diameter aluminum planchets were used in the study.

Sediment samples were collected with a hand corer at most stations and placed in 300 ml polypropylene bottles, returned to the laboratory and air dried at 30° C. using a temperature controlled oven. Each sample (95–240 g) of dried sediment was analyzed for the presence of selected gamma emitters using counting conditions similar to those described for seawater. After completion of the gamma counting of the individual samples for each sample period, composite samples were prepared and counted for the different sediment types (i.e. fibrous peat, fine mud, mud, or sandy) to allow for better comparison of the gamma radionuclide concentrations in the various sediment types.

Standardization and computer data analysis

The gamma spectrum analyses for determination of gamma ray energies and intensities of selected gamma emitters in Card Sound seawater and sediment samples were carried out using a modified Fortran IV, linear least squares fitting program described by Helmer, et al. (*2*) having zero-shift, gain-shift and intensity correction routines. The original gamma spectrum analysis program was written for the IBM 7040 Computer. The program was converted for use on the IBM 360/65 and Univac 1106 system and presently includes numerous updates and useful subroutines not available in the original program.

Calibrated, gamma-emitting standards were obtained from the Analytical Quality Control Service (AQCS), Bureau for Radiological Health,[7] and used to determine the photopeak counting efficiencies and minimal detectable activities[8] for the reported study. One liter water and sediment gamma standards were prepared by spiking either distilled water or ACS grade sodium chloride (density approximates sediment samples) with the appropriate gamma emitters for water and sediment standards, respectively. Following background subtraction and any gain-shift or zero-shift corrections, these data were then used as standardized gamma spectral input for the computer program. For each sample, the program calculates an intensity factor for each standard $\pm$ standard deviation and expresses the calculated activity of each standard emitter in appropriate units (i.e. per unit volume or unit weight).

Calibrated plutonium–239 and strontium-yttrium–90 sources were obtained from AQCS for use as alpha and beta standards, respectively. The final gross alpha and gross beta values were corrected for appropriate background, counting efficiency, backscatter and transmission factors.

[7] Now part of the Office of Research and Development, U.S. Environmental Protection Agency.

[8] Minimal detectable activities (MDA) $= 3\sqrt{\text{background}}$.

Results and discussion

Selected gamma radioactivity, seawater

The results of gamma spectral analysis carried out on Card Sound water samples taken between January 1971 and June 1972 are listed in table 1. The gamma analysis data indicated that the concentrations of the short half-life radionuclides (iodine–131, zirconium–95, and barium–140) as well as manganese–54, zinc–65, and sodium–22 were consistently nondetectable throughout the reporting period. Those gamma emitters having longer half-lives were present in detectable quantities in the water samples during the reporting period (table 1). Calculated mean activities for the longer-life species were indicative of a low background, marine system. For water samples, in general, there were no significant statistical differences at the 0.05 confidence level in the mean gamma emitting radionuclide concentrations between samples taken at different stations and only minimal variations between sample periods. Cerium–144 activities in water samples were consistent within each sample group, but showed statistically significant differences at the 0.05 confidence level in the mean concentration values when compared between sample periods (ranging from 48–253 pCi/liter). The higher values obtained for cerium–144 during the late sampling periods (1972) were due partly to improved cerium–144 counting conditions (i.e. reduction in the low energy background "noise" detected by the counting system).

Table 1. Selected gamma radioactivity in Card Sound water samples[a]

Date collected	Number of samples	Mean radionuclide concentrations (pCi/liter)					
		^{144}Ce	^{106}Ru	^{137}Cs	^{54}Mn	^{60}Co	^{40}K
11-13-70	40	62 ± 18	44 ± 7	16 ± 4	[b] T	T	212 ± 23
2-17-71	75	48 ± 20	T	ND	ND	ND	213 ± 18
3-24-71	70	54 ± 17	38 ± 4	T	T	ND	200 ± 19
6-22-71	55	218 ± 29	43 ± 6	17 ± 5	ND	13 ± 5	225 ± 18
10-3-71	56	189 ± 26	T	22 ± 6	ND	T	241 ± 22
1-11-72	50	253 ± 37	46 ± 6	T	ND	14 ± 6	225 ± 31
6-6-72	52	217 ± 23	35 ± 7	15 ± 5	T	11 ± 4	310 ± 30

[a] Sodium-22, zinc-65, zirconium-95, iodine-131, and barium-140 were not detected in any sample.
[b] Trace level, i.e., equal to MDA for that radionuclide, but occurring in >50 percent of the samples for that group, where $MDA = 3\sqrt{BKD}$.
[c] ND, nondetectable. Below background of counting system.

There were no statistically significant differences in means or variance between surface and bottom water sample gamma activity at the 95-percent confidence limit within each sample period. With the exception of cerium-144, only minimal differences in selected gamma radioactivity occurred during the entire reporting period.

Selected gamma radioactivity, sediments

The results of gamma analyses for sediment samples from Card Sound are listed in table 2. The mean gamma radioactivity concentrations (pCi/kg dried sediment) for the four sample groups between February 1971 and May 1972 showed significant differences between the first two sample periods and the final two sample periods. This was due partly to improved counting conditions (i.e. lower background), but mainly to the higher proportion of peat-type sediment samples present in the June 1971 and May 1972 collection periods. In general, the mean activities for selected gamma-emitting radionuclides ranged from nondetectable for iodine-131, zirconium-95, manganese-54, and barium-140 to greater than 1000 pCi/kg for cerium-144 (table 2).

When the composite samples were analyzed for each of the sampling periods and the mean activities of the different gamma emitters compared for the major sediment types (i.e. fibrous peat, mud, and sandy), it became apparent that the sediment-associated gamma radioactivities were not equally distributed between the sediment types (table 2). For example, the overall mean gamma concentrations of dried sediment for fibrous peat were greater than mud which were greater than sandy sediment. These differences in sediment-associated radioactivity could be important in influencing the distribution, availability, and ultimate uptake of biologically important radionuclides in Card Sound. A previous study (*3*) indicated that the movements of sediments in Card Sound are dominated by tidal circulation and wind-generated waves and currents, which distributes the coarser sediment in the upper and mid-portions of the sound, while the finer sediment materials are transported to and deposited across Card Bank. Assuming the sediment accociated radioactivity is dependent upon sediment type and radioactivity concentration increases with decreasing particle size (*4*) and based on hydrological and chemical analyses data obtained in the Card Sound study (*5,6*), one would expect the sediment in the Card Bank and adjacent areas (figure 2) to accumulate the highest concentrations of radioactivity derived from the Turkey Point reactor effluent discharges into Card Sound.

Gross alpha and beta radioactivity, Card Sound water

The results for the gross alpha and gross beta analyses of the 380 Card Sound water samples studied between November 1970 and June 1972 are listed in table 3. The gross alpha activities ranged from <3 pCi/liter (overall average also <3 pCi/liter) for suspended solids to means of 13–46 pCi/liter (overall mean 35

Table 2. Selected gamma radioactivity in Card Sound sediment samples

Date collected	Number of samples	Mean radionuclide concentrations (pCi/kg dry weight)										
		^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{65}Zn	^{60}Co	^{22}Na	^{40}K	^{140}Ba
2/17/71	72	691 ±60	ND	173 ±25	68 ±15	[a]T	T	20 ±12	48 ±15	27 ±12	480 ±55	ND
3/24/71	68	740 ±97	T	156 ±40	61 ±28	ND	ND	23 ±16	38 ±20	23 ±17	666 ±68	ND
6/22/71	36	925 ±115	ND	175 ±38	59 ±30	20 ±10	T	T	63 ±25	32 ±19	632 ±77	ND
5/6/72	24	1 010 ±222	T	212 ±60	88 ±32	30 ±21	T	28 ±16	68 ±24	30 ±20	682 ±71	ND
Composities												
2/17/71												
Sand	[b]3 (19)	435 ±40	ND	134 ±15	62 ±9	ND	ND	25 ±17	36 ±3	18 ±11	297 ±38	ND
Mud	3 (27)	656 ±51	T	149 ±12	68 ±11			20 ±7	42 ±12	23 ±5	517 ±53	ND
Peat	3 (26)	1 120 ±100	T	285 ±22	92 ±22	16 ±16	20 ±5	ND	85 ±20	35 ±7	1 060 ±182	ND
3/24/71												
Sand	3 (21)	416 ±36	ND	98 ±8	32 ±8	ND	ND	ND	22 ±8	21 ±11	229 ±18	ND
Mud	2 (14)	690 ±74	T	125 ±15	65 ±21	ND		31 ±8	28 ±6	T	544 ±49	ND
Peat	3 (20)	988 ±66	ND	222 ±27	90 ±15	T	31 ±12	48 ±21	77 ±19	40 ±8	1 220 ±125	ND
6/22/71												
Sand	2 (7)	415 ±33	ND	86 ±7	32 ±7	18 ±6	ND	ND	23 ±7	17 ±8	264 ±48	ND
Mud	2 (12)	591 ±51	ND	115 ±22	48 ±21	ND	T	ND	33 ±9	26 ±10	487 ±46	ND
Peat	2 (14)	1 290 ±76	T	281 ±37	85 ±21	25 ±7	23 ±5	40 ±18	96 ±21	42 ±14	1 150 ±98	ND
5/6/72												
Sand	1 (5)	452 ±39	ND	99 ±9	33 ±8	ND	ND	19 ±10	29 ±9	27 ±12	310 ±41	ND
Mud	2 (7)	639 ±55	ND	150 ±25	58 ±16	20 ±10	T	ND	52 ±17	30 ±6	499 ±46	ND
Peat	2 (12)	1 510 ±128	T	305 ±44	115 ±26	44 ±18	28 ±13	37 ±18	105 ±15	36 ±10	997 ±79	ND

[a] Trace level, i.e., equal to MDA for that radionuclide, but occurring in >50 percent of the samples for that group. Where $MDA = 3\sqrt{\overline{BKD}}$.
[b] Number in parentheses is the total number of individual samples included in the determination of the mean.
ND, nondetectable. Below background of counting system.

Table 3. Gross alpha and gross beta activity in Card Sound water

Date collected	Number of samples	Surface samples (pCi/liter)				Bottom samples (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
		Gross alpha	Gross beta	Gross alpha	Gross beta	Gross alpha	Gross beta	Gross alpha	Gross beta
1-13-71	38	<3	<6	[a] 13 ±29	251 ±107	<3	<6	32 ±40	266 ±92
2-17-71	71	<3	<6	46 ±40	259 ±71	<3	<6	30 ±36	236 ±70
3-24-71	70	<3	<6	35 ±31	265 ±80	<3	<6	38 ±23	252 ±83
6-22-71	48	<3	<6	40 ±31	255 ±69	<3	<6	41 ±29	259 ±91
10-3-71	56	<3	<6	37 ±30	273 ±75	<3	<6	33 ±35	271 ±67
1-11-72	50	<3	<6	32 ±30	260 ±78	<3	<6	45 ±32	282 ±76
6-6-72	48	<3	<6	28 ±23	280 ±85	<3	<6	32 ±27	272 ±88

[a] Mean ± standard deviation.

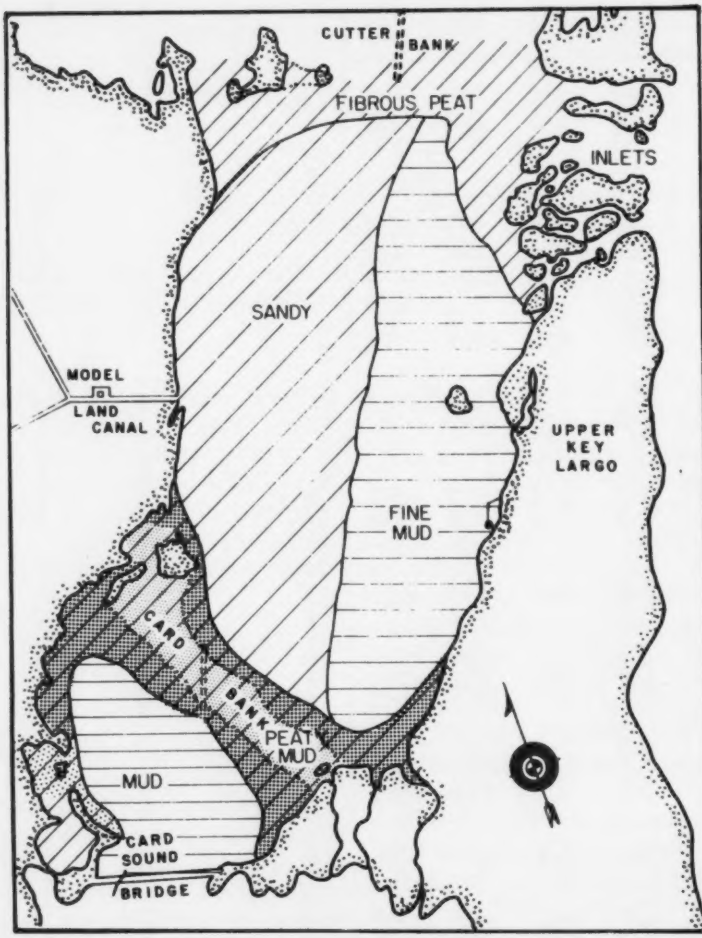

Figure 2. Card Sound system, showing approximate distributions of major sediment types (5), and projected regions of maximum sediment-associated radioactivity

pCi/liter) for the dissolved solids. Mean for gross beta radioactivity values for suspended solids and dissolved solids were <6 pCi/liter (overall mean <6 pCi/liter) and 251–282 pCi/liter (overall mean 263 pCi/liter), respectively.

Analyses of alpha and beta radioactivity data for the seven sampling periods covered in this report indicated that for both alpha and beta groups, there were no statistically significant differences in means at 0.05 level or variance at T + 0.05 (in general) between surface and bottom samples, between the means from different sample stations within each sample period, or between the means for the different sampling periods. Thus, the results of the gross alpha and gross beta radioactivity concentrations in Card Sound water samples during the reporting period were indicative of a low-background marine ecosystem with alpha or beta activity uniformly distributed throughout the entire body of water studied (figure 1).

Conclusions

The pre-Turkey Point Nuclear Power Plant operation levels of gross alpha, gross beta and

selected gamma radioactivity in Card Sound water during the reporting period (January 1971 to June 1972) were representative of a low-background, marine environment. These low-level radioactivities were randomly distributed throughout the small bay.

Sediment-associated, selected gamma radioactivity results suggest that the activities in dried sediment are distributed disproportionally between the major sediment types in Card Sound (i.e. fibrous peat > mud > sandy). These results, together with available hydrological (*5,6*) and sediment distribution data (*3*) would indicate the Card Bank and adjacent areas could be expected to show the highest sediment-associated radioactivity to be derived from FPL Turkey Point Nuclear Power Plant discharges into Card Sound.

The low-background randomly distributed levels of the radioactivity (gross alpha, gross beta and selected gamma) in Card Sound water prior to the operation of the Turkey Point Nuclear Power Plants provides a baseline for future studies designed to interpret radionuclide levels and distribution in Card Sound water during the period of FPL nuclear power plant effluent discharge into this marine ecosystem.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Procedures for determination of stable elements and radionuclides in environment samples, PHS No. 999-RH-10. Division of Radiological Health (1965); pp 3-1 to 3-12.

(*2*) HELMER, R. G., R. O. HEATH, L. A. SCHMITTROTH, M. A. JAYNE and L. M. WAGNER. Analysis of gamma-ray spectra from NaI(Tl) and Ge(Li) spectrometers—computer programs. Nucl Instru Methods 47:305–319 (1967).

(*3*) EARLEY, C. F. and H. G. GOODELL. The sediments of Card Sound, Florida. J Sedim Petrology 38:985–999 (1968).

(*4*) JOHNSON, Jr., R. H., and J. H. ABRAHAMS, Jr. Soil and sediment analysis: preparation for samples for environmental radiation surveillance, PHS Publication No. 999-RH-19. Division of Radiological Health (1966).

(*5*) An ecological study of South Biscayne Bay and Card Sound. Progress Report to US AEC (AT-(401)-3801-3) and Florida Power and Light Company (July 1971).

(*6*) An ecological study of South Biscayne Bay and Card Sound. Progress Report to US AEC (AT(40-1)-3801-4) and Florida Power and Light Company (June 1972).

Data

SECTION I. MILK AND FOOD

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–December 1972	February 1974
Carbon–14 in Total Diet and Milk	1972–1973	November 1973
Strontium–90 in Tri-City Diets	1972	December 1973

Radionuclides in Institutional Diet Samples, April–June 1973

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1,2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water—which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice

Figure 1. Institutional diet sampling locations as of June 1973

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children April-June 1973

Location of Institution		Month [a] (1973)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	April [b]	1.98	0.5	1.1	1.1	2.2	3	7	0	0
	Palmer		NS								
Ariz:	Phoenix	April	2.03	.6	1.2	1.5	3.0	3	6	0	0
Ark:	Little Rock	April	1.55	.6	1.0	1.8	2.8	0	0	0	0
Calif:	Los Angeles		NS								
	San Francisco	April [b]	1.66	.5	.8	1.8	3.0	3	5	0	0
Del:	Wilmington	April	1.56	.7	1.1	1.3	2.0	6	9	0	0
Fla:	Tampa	April	1.63	.5	.9	1.2	1.9	4	6	14	23
Hawaii:	Honolulu	April	2.49	.5	1.3	1.5	3.7	4	10	0	0
Idaho:	Idaho Falls	April [b]	1.75	.7	1.2	1.6	2.7	7	13	0	0
Ill:	Chicago		NS								
Ky:	Louisville		NS								
La:	New Orleans	April [b]	2.10	.5	1.0	1.5	3.3	6	13	0	0
Mass:	Boston	May	2.08	.6	1.2	1.5	3.2	4	7	0	0
Mo:	St. Louis	April [b]	1.25	.6	.8	1.9	2.4	4	5	0	0
Nebr:	Omaha	April [b]	2.41	.9	2.1	1.6	3.9	3	7	0	0
Nev:	Carson City	April	1.24	.5	.7	1.7	2.1	3	3	0	0
N. Mex:	Albuquerque	April [b]	1.74	.6	1.0	1.5	2.6	4	7	0	0
Ohio:	Cleveland		NS								
Oreg:	Portland	April [b]	2.07	.5	1.1	1.8	3.8	3	5	0	0
Pa:	Pittsburgh	April [b]	3.20	.4	1.2	1.3	4.1	3	10	13	42
S.C:	Charleston	April	.90	.5	.5	1.6	1.4	6	5	17	15
S. Dak:	Sioux Falls	April	.92	1.3	1.2	1.8	1.6	10	9	0	0
Tex:	Austin	April [b]	1.30	.6	.8	1.9	2.4	4	5	0	0
Utah:	Salt Lake City	April [b]	2.17	.4	.9	1.2	2.7	0	0	0	0
Wash:	Seattle	April [b]	1.87	.7	1.4	1.5	2.8	4	7	0	0
Institutional average			1.81	0.6	1.1	1.6	1.7	4	7	2	4

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.
NS, no sample.

and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (*3*).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during April–June 1973. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.81 kg/day compared to the network average of 1.84 kg/day observed from 1961 through 1972.

Strontium–90 dietary intake averaged 7 pCi/day during this period. Cesium–137 intake averaged 4 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium–89, barium–140, and iodine–131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2 standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium–89, 5 pCi/kg; strontium–90, 2 pCi/kg; iodine–131, 10 pCi/kg; barium–140, 10 pCi/kg; cesium–137, 10 pCi/kg.

This is the last data article for the Institutional Diet Sampling Program since this network was discontinued effective June 30, 1973.

Recent coverage in *Radation Data and Reports:*

Period	Issue
April–June 1972	July 1973
July–September 1972	August 1973
October–December 1972	September 1973
January–March 1973	November 1973

REFERENCES

(*1*) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402 (September 1961).

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium–226 and strontium–90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	January–December 1972	December 1973
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Radioactivity in Minnesota Municipal Water Supplies[1] July 1971–June 1972

Division of Environmental Health
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul. Beginning in November 1969, weekly samples from these stations were composited and analyzed on a monthly basis. Monthly samples are taken at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 500-ml sample of water is evaporated into a 2-inch aluminum

[1] Data and information from "Survey of environmental radioactivity, July 1971–June 1972," Publication No. C00-651-87. Minnesota Department of Health, 717 Delaware St. S.E., Minneapolis, Minn. 55440.

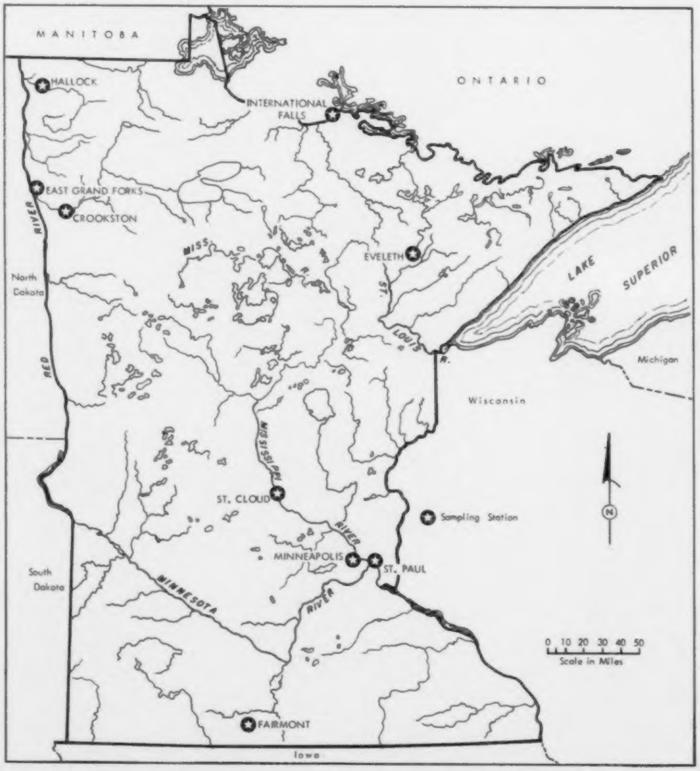

Figure 1. Minnesota surface water sampling locations

Table 1. Average gross beta radioactivity in Minnesota raw and treated water supplies, July 1971-June 1972

Town and water source	Type of water	Average concentration (pCi/liter)											
		1971						1972					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	22	21	18	18	35	17	17	22	18	14	17	19
	Treated	22	16	16	17	13	19	16	20	18	11	14	15
East Grand Forks, Red River Lake	Raw	21	17	19	20	18	16	18	19	16	13	14	17
	Treated	6	8	10	15	11	9	6	7	10	9	8	7
Eveleth, St. Mary's Lake	Raw	13	12	12	12	7	7	10	11	11	13	9	8
	Treated	9	10	12	12	10	9	10	9	9	9	11	7
Fairmont, Budd Lake	Raw	9	11	9	11	9	8	15	8	8	9	8	8
	Treated	6	6	5	11	5	3	7	4	4	5	6	3
Hallock, Two Rivers South Fork	Raw	21	16	16	13	12	16	19	19	16	10	14	13
	Treated	8	6	7	7	4	7	9	14	7	8	6	7
International Falls, Rainey River	Raw	12	9	8	7	8	6	4	8	6	4	10	7
	Treated	24	9	6	7	4	5	4	6	3	6	5	6
Minneapolis tap water	Treated	9	4	7	13	5	4	6	<2	5	5	8	6
St. Cloud, Mississippi River	Raw	NS	10	9	9	14	8	6	NS	6	10	NS	9
	Treated	NS	7	5	4	8	5	4	NS	3	3	NS	5
St. Paul, Vadnais Chain of Lakes	Raw	15	10	11	12	12	13	10	10	11	10	10	8
	Treated	8	7	8	9	6	5	6	7	8	5	6	6

NS, no sample.

Table 2. Average gross alpha radioactivity in Minnesota raw and treated water supplies, July 1971-June 1972

Town and water source	Type of water	Average concentration (pCi/liter)											
		1971						1972					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<3	<4	<3	<4	15	<4	<2	<2	<2	3	<4	<4
	Treated	<2	<2	<3	<3	4	<4	<3	<2	<2	<2	<3	<3
East Grand Forks, Red River Lake	Raw	<3	<4	<4	6	<4	<3	7	<3	<2	<2	<5	<4
	Treated	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Eveleth, St. Mary's Lake	Raw	<2	<2	<2	<3	<1	<3	<2	<1	<2	<2	<1	<2
	Treated	<2	<2	<2	<2	<1	<2	2	<2	<2	<2	<2	<2
Fairmont, Budd Lake	Raw	<2	<4	<1	<4	6	7	17	4	5	<4	<3	6
	Treated	<2	<2	<2	<2	<2	<2	6	3	<2	<2	<2	<2
Hallock, Two Rivers South Fork	Raw	<5	<5	<6	<4	<3	<4	11	<5	<5	<4	<4	<4
	Treated	<2	<2	<2	<3	<2	<2	<3	<3	<3	<2	<2	<2
International Falls, Rainey River	Raw	<1	<1	<1	<1	<1	<1	<2	<2	<1	<1	<1	<1
	Treated	<2	<2	<1	<1	<1	<1	<2	<2	<1	<2	<1	<1
Minneapolis tap water	Treated	<2	<2	<1	<4	<2	<2	<3	<2	<2	<2	<2	<2
St. Cloud, Mississippi River	Raw	NS	<3	<1	<2	6	<3	<2	NS	<2	<2	NS	<4
	Treated	NS	<3	<1	<1	<2	<2	<2	NS	<2	<7	NS	<2
St. Paul, Vadnais Chain of Lakes	Raw	<3	<2	<3	<3	<2	<3	<2	<2	<3	<3	<3	<2
	Treated	<2	<2	<2	<2	<2	<2	<3	<2	<2	<2	<2	<2

NS, no sample

milk bottle lid planchet and counted in an internal-proportional gas flow counter. The counter is calibrated with a cesium–137 standard.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal supplies from July 1971–June 1972. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 4 to 35 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July 1970–June 1971	November 1972

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered in *Radiation Data and Reports*.

Network	Period reported	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican air monitoring program	January–June 1973	December 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	1971	September 1973

Krypton-85 in Air, July 1970 to December 1972

Eastern Environmental Radiation Facility
U.S. Environmental Protection Agency

Krypton–85 in the atmosphere results from natural production by cosmic ray interactions, thermonuclear detonations, and atmospheric releases from several components of the nuclear power industry. Monitoring of krypton–85 in the atmosphere has been conducted to identify baseline levels and trends in anticipation of a nationwide expansion of the nuclear power industry.

The analytical results for 1970–1972 are presented in table 1. The krypton–85 in air data are presented for several locations throughout the United States, selected with respect to existing and proposed nuclear power reactor and nuclear fuel reprocessing plant locations. Dry, compressed air samples were purchased from commercial air suppliers and analyzed for krypton–85 by the method of Cummings, et al. (*1*).

The analysis of krypton–85 in air will continue as a component of the Environmental Radiation Ambient Monitoring System (ERAMS) and the data reported in *Radiation Data and Reports* on a semiannual basis.

REFERENCE

(*1*) CUMMINGS, S. L., R. L. SHEARIN, and C. R. PORTER. A rapid method of determining ^{85}Kr in environmental air samples. Proceedings of the International Symposium on Rapid Methods for Measurement of Radioactivity in the Environment (1971), pp. 163–169.

Table 1. Krypton–85 in air, July 1970 to December 1972

Location		Krypton-85 concentration (pCi/m³ of air at STP [a])							
		1970		1971				1972 [b]	
		July 1–Sept 30	Oct 1–Dec 31	Jan 1–March 31	April 1–June 30	July 2–Sept 30	Oct 1–Dec 31	Jan 1–March 31	April 1–June 30
Ala:	Montgomery	—	—	15.8	15.2	14.3	14.7	13.8	14.4
Calif:	Long Beach [c]	—	14.8	14.4	14.6	14.4	—	—	14.3
	Oakland	—	—	—	14.6	14.2	14.5	15.1	14.3
Colo:	Denver [c]	16.2	16.9	—	—	—	—	16.4	—
Fla:	Tampa	—	—	14.4	14.2	14.3	—	12.8	15.1
Ill:	Chicago	—	—	—	14.7	14.5	15.5	14.2	—
Mass:	Boston	—	15.2	15.2	—	14.8	14.9	—	15.4
Mich:	Detroit	—	14.4	15.8	13.9	14.7	14.6	15.5	15.7
N.J:	Camden	—	15.6	15.2	14.7	13.7	15.1	13.6	16.3
N.Y:	Buffalo	—	—	14.9	15.7	14.8	15.9	16.1	15.4
	Rochester [c]	—	—	—	15.2	—	—	—	—
	Utica	—	—	—	15.1	14.1	14.7	14.7	14.0
N.C:	Greensboro	—	15.7	14.7	14.4	14.5	14.8	15.7	15.0
Okla:	Oklahoma City	—	—	14.9	14.5	13.6	15.0	14.8	14.2
Oreg:	Portland	—	—	—	—	15.1	—	—	—
Wash:	Spokane	—	—	—	—	—	—	—	14.8

[a] Standard temperature and pressure.
[b] No samples were collected for July-December 1972.
[c] 2σ error $< \pm 10$ percent.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follows for Mound Laboratory and the National Reactor Testing Station.

[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Mound Laboratory[2]
January–December 1971

Monsanto Research Corporation
Miamisburg, Ohio

Mound Laboratory is situated on 180 acres of land in Miamisburg, Ohio, about 12 miles southwest of Dayton. The laboratory began operation in 1949. Its mission currently includes research, development, engineering, and production of components for the AEC weapons program; research, development and production of explosive materials; separation, purification, and sale of stable isotopes of the noble gases; and development, design and fabrication of radioisotopic heat sources for medical application and space exploration. The area within a 20-mile radius of the laboratory includes essentially all of Montgomery County and approximately 30 to 60 percent of the adjoining counties of Butler, Greene, Preble, and Warren. The predominant geographical feature in the five county region is the Great Miami River which flows through Miamisburg from the northeast to the southwest. This river valley area is generally highly industrialized. The remainder of the region is predominantly agricultural with some light industry and scattered residential communities. The primary agricultural activity in the area is raising field crops such as corn and soybeans. Approximately 10 percent of the land area in agricultural use is devoted to pasturing livestock (*1*).

Weather conditions in the area are considered moderate. The average annual precipitation is approximately 36 inches and is distributed evenly throughout the year. Winds predominate

[2] Summarized from "Environmental Monitoring Report, January-December 1971 and 1971 Summary" (MLM 1922).

out of the south and west except during the summer months when a higher frequency is observed out of the southwest. The wind speed averages about 10 miles per hour annually (*2*).

Interest in the health and safety of employees and the public is manifested by an Environmental Control Program which has been in existence continuously during the laboratory's history. Fundamental objectives of the environmental control program are the containment of radioactive waste and control of nonradioactive effluents to levels well within existing or proposed standards. As part of the program's control function, all effluents containing polluting materials are controlled at each operating step. As a result of this control, any releases of low-level gaseous and liquid wastes to the environment are carefully controlled and dispersed to ensure that concentrations are well within recommended standards.

Air monitoring

Air samples are collected offsite three times per week by means of a mobile sampling unit mounted in a panel truck. Samples are collected upwind and downwind as far as 20 miles from the laboratory covering an area of 1250 square miles. Specific collection routes are drawn for the different wind directions. The route is selected on any given day corresponding to the wind direction for that day. Figure 1 shows the zones corresponding to the eight sampling routes. The mobile unit is parked safely off the road while the sample is taken. Two types of samples are collected, a particulate sample for plutonium–238 and polonium–210 analysis and a gas bubbler sample for tritium oxide analysis. The particulate sample is collected on a 4-inch diameter Whatman No. 41 filter paper by means of a high volume air sampler. The air is sampled at a rate of 20 cubic feet per minute ($0.57\ m^3$/

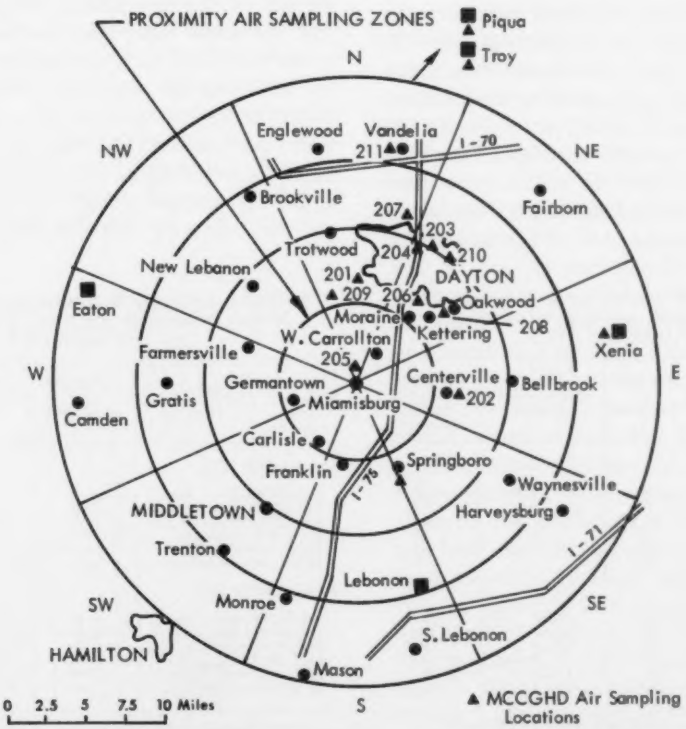

Figure 1. Offsite air sampling zones, Mound Laboratory

min). The particulate sample collected represents approximately 10 m^3 of air and is analyzed specifically for polonium–210 and plutonium–238. The plutonium–238 analysis includes the use of plutonium–236 as an internal standard in conjunction with alpha pulse-height analysis which allow for correction of chemical and counting losses to be made.

Analysis of the monitoring data for January–June 1971, shows that the average concentration of the polonium–210 measured at all locations upwind and downwind in all zones was only slightly above 0.1 percent of the AEC standard. The AEC standard is the concentration of radioactivity in the environment which is determined to result in whole body or organ doses which should not be exceeded without careful consideration. The data demonstrate that the average concentrations in all sampling areas were well below that level. The highest average concentration for this report period was 0.13 percent of the AEC standard in the 0–3 mile range upwind and 5–10 mile range downwind.

Analysis of the data obtained from samples collected by the mobile unit during July–December 1971 shows that the average concentrations of polonium–210 measured at all locations upwind and downwind in all zones were less than 0.3 percent of the AEC standard. The average concentrations over the entire year were approximately 0.2 percent of the AEC standard. These results are summarized in tables 1 and 2.

Table 2. Atmospheric monitoring for polonium–210 Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average as percent of AEC standard[b]
0–3 (upwind)	134	12±8	0.2
0–3 (downwind)	134	10±6	.1
3–5 (downwind)	134	10±7	.1
5–10 (downwind)	134	14±8	.2
10–15 (downwind)	134	13±8	.2
15–20 (downwind)	134	9±5	.1

[a]Lowest detectable limit for polonium–210 in air is 2 fCi/m^3.
[b] The applicable AEC radiation protection standard for polonium–210 in air is 7 pCi/m^3.

Plutonium–238 concentrations measured in all zones for January–June were less than 1 percent of the AEC standard with a maximum of 0.57 percent occurring in the 0–3 mile range upwind. Plutonium–238 concentrations measured in samples collected by the mobile unit in all zones were less than 2 percent of the AEC standard. The average concentrations for the entire year were 1 percent of the AEC standard or less. Results for January–December 1971 are shown in tables 3 and 4. Samples are collected (at the same time that particulate samples of plutonium–238 and polonium–210 are taken) by bubbling air through 100 ml of p-dioxane-based scintillation fluid at a rate of 0.35 cubic feet per minute (9900 cm^3/min). Tritium oxide is collected in the p-dioxane solution, and a 20 ml aliquot of the resulting solution is counted directly for 10 minutes in a liquid

Table 1. Atmospheric monitoring for polonium–210, Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average percent of AEC standard[b]
January-June 1971:			
0–3 (upwind)	70	9.5	0.13
0–3 (downwind)	70	8.1	.12
3–5 (downwind)	70	7.3	.10
5–10 (downwind)	70	9.4	.13
10–15 (downwind)	70	7.7	.11
15–20 (downwind)	70	6.7	.10
July-December 1971:			
0–3 (upwind)	64	14±8	.2
0–3 (downwind)	64	13±5	.2
3–5 (downwind)	64	14±8	.2
5–10 (downwind)	64	19±9	.3
10–15 (downwind)	64	18±9	.3
15–20 (downwind)	64	10±9	.1

[a]Lowest detectable limit for polonium–210 in air is 2 fCi/m^3.
[b]The applicable AEC radiation protection standard for polonium–210 in air is 7 pCi/m^3.

Table 3. Atmospheric monitoring for plutonium–238 Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average as percent of AEC standard[b]
January-June 1971:			
0–3 (upwind)	72	1.70	0.57
0–3 (downwind)	72	1.36	.45
3–5 (downwind)	71	1.21	.40
5–10 (downwind)	66	1.35	.45
10–15 (downwind)	68	1.32	.44
15–20 (downwind)	64	1.33	.44
July-December 1971:			
0–3 (upwind)	44	3.19±0.47	1.1
0–3 (downwind)	44	5.58± .51	1.9
3–5 (downwind)	44	2.08± .38	.7
5–10 (downwind)	44	2.04± .38	.7
10–15 (downwind)	44	1.45± .32	.5
15–20 (downwind)	44	2.81± .36	.9

[a]Lowest detectable limit for plutonium–238 in air is 0.03 fCi/m^3.
[b] The applicable AEC radiation standard for plutonium–238 in air is 300 fCi/liter.

Table 4. Atmospheric monitoring for plutonium-238 Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m³)	Average as percent of AEC standard[b]
0-3 (upwind)	116	2.27±0.39	0.8
0-3 (downwind)	116	2.96± .37	1.0
3-5 (downwind)	115	1.54± .33	.5
5-10 (downwind)	110	1.63± .34	.5
10-15 (downwind)	112	1.37± .31	.5
15-20 (downwind)	108	1.93± .30	.6

[a] Lowest detectable limit for plutonium-238 in air is 0.03 fCi/m³.
[b] The applicable AEC radiation protection standard for plutonium-238 in air is 300 fCi/m³.

scintillation spectrometer. The sampling and analysis is directed to tritium oxide rather than the gas since the AEC standard for the oxide is 200 times more restrictive.

The highest average concentration of tritium oxide detected in the environment during January-June was 2.22 percent of the AEC standard in the 0-3 mile range downwind. The concentration diminished to less than 0.7 percent in the 3-5 mile range downwind. The average concentrations of tritium oxide measured during July-December varied approximately 6 percent of the AEC standard in one range (0 to 3 miles downwind) to 0.5 percent of the AEC standard. The average concentrations for the entire year varied from 4 percent to 0.5 percent of the AEC standard. These results are summarized in tables 5 and 6.

Table 5. Atmospheric monitoring for tritium, Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (pCi/m³)	Average as percent of AEC standard[b]
January-June 1971:			
0-3 (upwind)	71	409	0.58
0-3 (downwind)	71	1 557	2.22
3-5 (downwind)	71	473	.68
5-10 (downwind)	71	378	.54
10-15 (downwind)	71	357	.51
15-20 (downwind)	71	428	.61
July-December 1971:			
0-3 (upwind)	65	840±120	1.2
0-3 (downwind)	65	4 330±190	6.2
3-5 (downwind)	65	1 070±120	1.5
5-10 (downwind)	65	450±110	.6
10-15 (downwind)	65	360±110	.5
15-20 (downwind)	65	480±110	.7

[a] Lowest detectable limit for tritium in air is 50 pCi/m³ for January-June and 40 pCi/m³ for July-December.
[b] The applicable AEC radiation standard for tritium in air is 70 nCi/m³.

Table 6. Atmospheric monitoring for tritium, Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (pCi/m³)	Average as percent of AEC standard[b]
January-December 1971:			
0-3 (upwind)	136	610±110	0.9
0-3 (downwind)	136	2 880±160	4.1
3-5 (downwind)	136	760±120	1.1
5-10 (downwind)	136	410±110	.6
10-15 (downwind)	136	360±110	.5
15-20 (downwind)	136	450±110	.6

[a] Lowest detectable limit for tritium in air is 40 pCi/m³.
[b] The applicable AEC radiation standard is 70 nCi/m³.

Additional particulate air samples are obtained from the Air Pollution Control Section of the Montgomery County Combined General Health District (MCCGHD). These samples are collected from various locations in Montgomery County. The locations also can be found in figure 1. The particulate sample in this case is collected on a 8 × 10 inch fiberglass filter by means of a high-volume air sampler. The air is sampled at a rate of 40 cubic feet per minute (1 m³/min.) for a 24-hour period every 4 days. This sample represents approximately 1600 m³ of air. The MCCGHD determines the weight of particulates collected and then submits one-half of the filter to Mound Laboratory which is analyzed specifically for polonium-210 and plutonium-238. The MCCGHD also supplies particulate data from the network to Mound Laboratory. Analysis of the data obtained from the MCCGHD particulate air samples during 1971 indicate that the average concentration of polonium-210 and plutonium-238 detected at any location was approximately 0.1 percent or less of the AEC standard. During the last quarter of 1971, additional particulate samples from communities outside Montgomery County were made available by the MCCGHD. While not as many samples were obtained from these locations as the Montgomery County locations, they are included for comparison since they are distant enough (19 to 34 miles) to be considered background for this general area. The concentrations of polonium-210 measured at the Montgomery County locations are approximately the same as the concentrations measured at the distant locations. The polonium-210 results are summarized in table 7. The concentra-

Table 7. Summary of Montgomery County combined General Health District air monitoring data for polonium–210, January-December 1971

Location	Average concentration (fCi/m³)	Percent of AEC standard[a]
201	4.61±0.46	0.07
202	3.83± .39	.05
203	4.57± .46	.07
204	4.90± .47	.07
205	5.18± .47	.07
206	5.72± .50	.08
207	8.14± .71	.12
208	5.38± .47	.08
209	4.84± .45	.07
210	5.09± .45	.07
211	4.90± .46	.07
Piqua, Ohio[b]	7.84± .67	.11
Troy, Ohio[b]	7.80± .71	.11
Springfield, Ohio[b]	7.47± .66	.11
Springfield, Ohio[b]	7.47± .68	.11
Springfield, Ohio[b]	7.18± .64	.10
Fairborn, Ohio[b]	7.97± .70	.11
Xenia, Ohio[b]	8.04± .72	.11

[a] AEC standard = 7 pCi/m³. Lowest detectable limit for polonium in air for MCCGHD samples is 0.01 fCi/m³.
[b] Stations outside Montgomery County.

tions of plutonium–238 measured at the Montgomery County locations are of the same order of magnitude as the concentrations measured at the distant stations with the highest average value being a factor of 5 greater than the average value of the seven distant stations. This highest average value, however, is only 0.05 percent of the AEC standard. The plutonium–238 results are summarized in table 8. The data obtained from the MCCGHD samples indicate the increased sensitivity achieved by sampling a larger volume of air in comparison to the routine samples collected by the mobile unit (1000 m³ vs 10 m³). These data further

Table 8. Summary of Montgomery County Combined General Health District air monitoring data for plutonium–238, January-December 1971

Location	Average concentration (aCi/m³)	Percent of AEC standard[a]
201	26.5± 6.4	0.009
202	18.7± 4.9	.006
203	81.9±11.2	.027
204	19.1± 5.3	.006
205	77.6±10.5	.026
206	140.9±14.3	.047
207	40.1± 9.1	.013
208	19.6± 5.3	.007
209	117.7±13.3	.039
210	48.8± 8.2	.016
211	53.8± 8.8	.018
Piqua, Ohio[b]	32.7± 7.9	.011
Troy, Ohio[b]	25.2± 7.4	.008
Springfield, Ohio[b]	21.8± 6.4	.007
Springfield, Ohio[b]	18.9± 6.2	.006
Springfield, Ohio[b]	33.3± 8.0	.011
Fairborn, Ohio[b]	14.4± 5.4	.005
Xenia, Ohio[b]	42.5±10.0	.014

[a] AEC standard for plutonium–238 is 0.3 pCi/m³. Lowest detectable limit for plutonium in air for MCCGHD samples is 1.9 aCi/m³.
[b] Stations outside Montgomery County.

demonstrate that the average concentrations of polonium–210 and plutonium–238 in the environment are well below the AEC standards.

A continuously operating high volume air sampler and gas bubbler have been in operation in Miamisburg since the middle of September 1971. The sampler is located approximately 1 mile due north of the laboratory. The high volume sampler collects a particulate sample on a 200 mm diameter Microsorban disk. The sampling rate is 40 cubic feet per minute (1.1 m³/min) resulting in a total sample volume of 10 000 m³ of air. The gas bubbler sample also is collected on a continuous basis at approximately 1000 cm³/min with a total volume of 10³ m of air sampled. The average concentration of polonium–210 detected at the continuous high volume air sampling station in Miamisburg was only 0.03 percent of the AEC standard and the average concentration of plutonium–238 detected at this location was only 0.01 percent of the AEC standard. The average concentration of tritium oxide detected at this location was only 1 percent of the AEC standard. The data obtained from the continuous air sampling station demonstrates the increase in sensitivity achieved by collecting very large samples or air for both particulate samples (~10 000 m³) and gas bubbler samples (10 m³). A network of 10 continuous high volume air sampling stations is scheduled to be in operation by mid-February 1972 with an additional 10 planned to be in operation during the second half of 1972.

An onsite perimeter network of five continuous, high volume air samplers is scheduled for installation during the first half of 1972. In the interim, three sampling stations have been in operation. A continuous, high volume air sampler has been located at the southern site perimeter. The air is sampled at the rate of 40 cubic feet per minute (1.1 m³/min). The remaining two sampling stations contain continuous low-volume air samplers. In these cases air is sampled at the rate of 1-cubic foot per minute (0.03 m³/min). One low-volume station is located at approximately the center of the site and the other at the northern site perimeter. Gas bubbler samples at the rate of 1000 cm³/min also are collected at all three sampling

locations. Both high and low volume particulate samples are analyzed for polonium–210 and plutonium–238. The average concentrations of polonium–210, plutonium–238 and tritium oxide detected during 1971 at the onsite high volume air sampling station were 0.01 percent, 0.05 percent, and 0.07 percent of their respective AEC standards. The average concentration of polonium–210, plutonium–238 and tritium oxide detected during 1971 at the onsite low volume air sampling station located at the site center were 0.02 percent, 0.04 percent, and 2.7 percent of their respective AEC standards. These values for the other low volume air sampling station located at the northern perimeter were 0.01

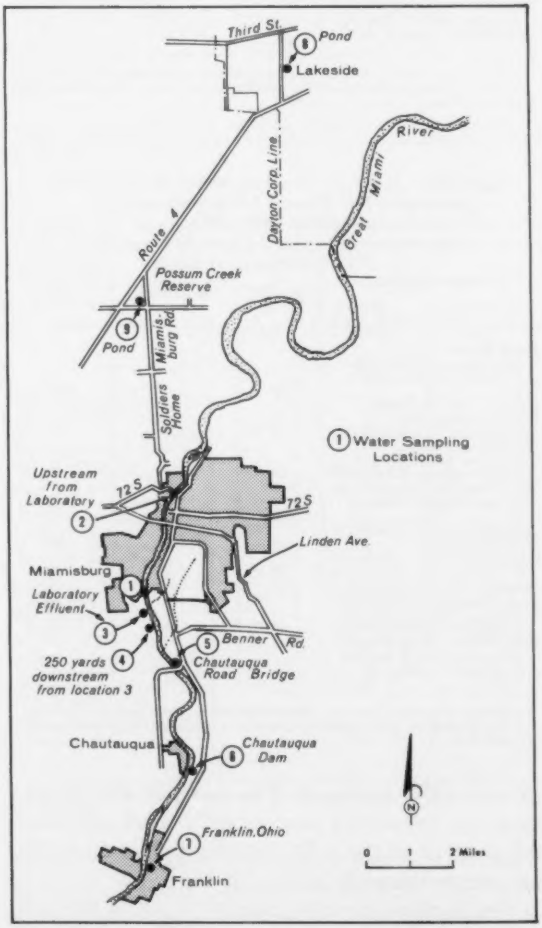

Figure 2. Water monitoring stations, Mound Laboratory

percent, 0.03 percent, and 2.4 percent, respectively.

Water monitoring

During January through June 1971, water samples were collected twice per week along the bank of the Great Miami River and from two ponds northeast of the laboratory. Analysis of these samples is performed using equipment which is capable of detecting radioactivity far below the AEC standard. All samples are analyzed for polonium–210, plutonium–238, and tritium oxide. A sample of approximately 200 ml was taken at each of 9 sampling locations during January–June and a 500 ml sample was taken during July–December. These locations are shown in figure 2.

The highest average concentration of polonium–210 detected during January–June at any sampling location was 2.82 percent of the AEC standard. This was detected 230 meters downstream from the Mound Laboratory effluent. A number is reported in the table because a value was assigned to those samples which were determined to be below the detectable limit. The number assigned to those samples was arrived at by multiplying the lowest detectable limit for polonium by a fraction which was the number of samples above the limit divided by the total number of samples analyzed.

Analysis of data obtained from water samples taken during July–December 1971 indicates that the average concentrations of polonium–210 detected were less than 1 percent of the AEC standard. The average concentrations for the entire year of 1971 were less than 2 percent of the AEC standard. These polonium–210 results are summarized in tables 9, 10, and 11.

Plutonium–238 concentrations measured at all locations were less than 1 percent of the AEC standard with the maximum being 0.26 percent of the AEC standard. This was detected 10 feet downstream from the point the Mound Laboratory effluent enters the Great Miami River (locations 3 in figure 2). The average concentrations found at the remainder of the Great Miami River locations downstream from the Mound Laboratory outfall were at approxi-

Table 9. Summary of offsite water monitoring for polonium–210, Mound Laboratory environs, January-June 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	50	1.09	0.55
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	50	.28	.14
Great Miami River, 3 meters downstream from Mound effluent (location 3)	50	5.33	2.67
230 meters downstream from Mound effluent (location 4)	50	5.65	2.82
Chautauqua Road Bridge (location 5)	50	.59	.29
Chautauqua Dam (location 6)	50	.45	.22
Franklin, Ohio (location 7)	50	.51	.25
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound (location 8)	50	.33	.17
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	50	.52	.26

[a] Lowest detectable limit for polonium in water is 1.28 pCi/liter.
[b] The applicable AEC radiation protection standard for polonium–210 is 200 pCi/liter.

Table 10. Summary of offsite water monitoring for polonium–210, Mound Laboratory environs, July-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	49	0.7±0.4	0.3
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	49	.7± .4	.3
Great Miami River, 3 meters downstream from Mound effluent (location 3)	49	1.9± .6	.9
230 meters downstream from Mound effluent (location 4)	49	.7± .4	.3
Chautauqua Road Bridge (location 5)	49	.8± .4	.4
Chautauqua Dam (location 6)	49	.8± .4	.4
Franklin, Ohio (location 7)	48	.7± .4	.3
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	49	.7± .4	.3
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	33	.8± .4	.4

[a] Lowest detectable limit for polonium in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for polonium–210 is 200 pCi/liter.

Table 11. Summary of offsite water monitoring for polonium–210, Mound Laboratory environs, January-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	99	0.9±0.5	0.4
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	99	.5± .4	.2
Great Miami River, 3 meters downstream from Mound effluent (location 3)	99	3.6± .8	1.8
230 meters downstream from Mound effluent (location 4)	99	3.2± .7	1.6
Chautauqua Road Bridge (location 5)	99	.7± .4	.3
Chautauqua Dam (location 6)	99	.6± .4	.3
Franklin, Ohio (location 7)	98	.6± .4	.3
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	99	.5± .4	.2
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	83	.6± .4	.3

[a] Lowest detectable limit for polonium–210 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for polonium–210 is 200 pCi/liter.

Table 12. Summary of offsite water monitoring for plutonium–238, Mound Laboratory environs, January-June 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami Riyer, 23 meters upstream from Mound effluent (location 1)	50	1.8	0.09
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	50	1.3	.07
Great Miami River, 3 meters downstream from Mound effluent (location 3)	50	5.2	.26
230 meters downstream from Mound effluent (location 4)	50	3.8	.19
Chautauqua Road Bridge (location 5)	50	1.5	.07
Chautauqua Dam (location 6)	50	1.4	.07
Franklin, Ohio (location 7)	50	1.8	.09
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	50	1.0	.05
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	50	.8	.04

[a] Lowest detectable limit for plutonium–238 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for plutonium–238 is 2 nCi/liter.

mately the same concentration level as found at the sampling location upstream from Mound Laboratory outfall (location 2 in figure 2). Average concentrations of plutonium–238 measured during July–December 1971 at all sampling locations were less than 0.1 percent of the AEC standard. The average concentrations for the entire year of 1971 were less than 0.2 percent of the AEC standard. These results are summarized in tables 12–14.

The highest average concentration of tritium oxide for January–June was 4.74 percent of

Table 13. Summary of offsite water monitoring for plutonium–238, Mound Laboratory environs, July-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	49	1.3±0.5	0.07
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	49	1.0± .5	.05
Great Miami River, 3 meters downstream from Mound effluent (location 3)	49	1.5± .5	.08
230 meters downstream from Mound effluent (location 4)	49	1.3± .5	.07
Chautauqua Road Bridge (location 5)	49	1.1± .5	.06
Chautauqua Dam (location 6)	49	1.0± .5	.05
Franklin, Ohio (location 7)	48	.8± .4	.04
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	49	.9± .5	.05
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	33	.8± .4	.04

[a] Lowest detectable limit for plutonium–238 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for plutonium–238 is 2 nCi/liter.

Table 14. Summary of offsite water monitoring for plutonium–238, Mound Laboratory environs, January-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	99	1.5±0.5	0.08
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	99	1.1± .5	.06
Great Miami River, 3 meters downstream from Mound ML effluent (location 3)	99	3.4± .8	.17
230 meters downstream from Mound effluent (location 4)	99	2.5± .6	.13
Chautauqua Road Bridge (location 5)	99	1.3± .5	.07
Chautauqua Dam (location 6)	99	1.2± .5	.06
Franklin, Ohio (location 7)	98	1.2± .5	.06
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound (location 8)	99	1.0± .5	.05
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound (location 9)	83	.8± .4	.04

[a] Lowest detectable limit for plutonium–238 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for plutionium–238 is 2 nCi/liter.

the AEC standard, detected 10 feet downstream from the Mound Laboratory effluent. The next highest average concentration detected was 2.74 percent of the AEC standard, 250 yards downstream from the laboratory effluent. The average concentrations found at the remainder of the Miami River sampling locations downstream from the laboratory outfall were below the concentration detected upstream from the outfall. Analysis of the tritium oxide data obtained from these biweekly water samples during the second half of 1971 indicates that the average concentration was less than 1 percent of the AEC standard. The average concentrations for the entire year of 1971 were less than 2.8 percent of the AEC standard. These results are summarized in tables 15–17.
are summarized in tables 15–17.

Table 15. Summary of offsite water monitoring for tritium, Mound Laboratory environs, January-June 1971

Sample location	Number of samples	Average concentration[a] (nCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	50	18.5	1.85
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	50	6.8	.68
Great Miami River, 3 meters downstream from Mound effluent (location 3)	50	47.4	4.74
230 meters downstream from Mound effluent (location 4)	50	27.4	2.74
Chautauqua Road Bridge (location 5)	50	4.8	.48
Chautauqua Dam (location 6)	50	3.0	.30
Franklin, Ohio (location 7)	50	3.0	.30
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	50	5.5	.55
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	50	9.0	.90

[a] Lowest detectable limit for tritium in water is 0.2 nCi/liter.
[b] The applicable AEC radiation protection standard for tritium is 1000 nCi/liter.

Eight additional surface water locations such as ponds and streams are sampled monthly. A sample of approximately 4 liters is collected at each location and analyzed for polonium–210, plutonium–238, and tritium oxide. The average concentrations of polonium–210 measured at the surface water locations during 1971 were less than 0.1 percent of the AEC standard. The average concentrations of plutonium–238 measured at these locations during 1971 were less than 0.01 percent of the AEC standard. The average concentrations of tritium oxide meas-

Table 16. Summary of offsite water monitoring for tritium, Mound Laboratory environs, July-December 1971

Sample location	Number of samples	Average concentration[a] (nCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	49	5.5±0.3	0.55
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	49	1.3± .2	.13
Great Miami River, 3 meters downstream from Mound effluent (location 3)	49	8.1± .4	.81
230 meters downstream from Mound effluent (location 4)	49	3.5± .3	.35
Chautauqua Road Bridge (location 5)	49	1.9± .2	.19
Chautauqua Dam (location 6)	49	1.7± .2	.17
Franklin, Ohio (location 7)	48	1.7± .2	.17
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	41	2.5± .2	.25
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	33	4.5± .3	.45

[a] Lowest detectable limit for tritium in water is 0.2 nCi/liter.
[b] The applicable AEC radiation protection standard for tritium is 1000 nCi/liter.

Table 17. Summary of offsite water monitoring for tritium, Mound Laboratory environs, January-December 1971

Sample location	Number of samples	Average concentration[a] (nCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	99	12.0±0.5	1.20
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	99	3.8± .3	.38
Great Miami River, 3 meters downstream from Mound effluent (location 3)	99	27.9± .7	2.79
230 meters downstream from Mound effluent (location 4)	99	15.5± .6	1.55
Chautauqua Road Bridge (location 5)	99	3.3± .3	.33
Chautauqua Dam (location 6)	99	2.4± .2	.24
Franklin, Ohio (location 7)	98	2.3± .2	.23
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	91	4.1± .3	.41
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	83	7.2± .4	.72

[a] Lowest detectable limit for tritium in water is 0.2 nCi/liter.
[b] The applicable AEC radiation protection standard for tritium is 1000 nCi/liter.

Table 18. Summary of surface water monitoring, January-December 1971

Location	Average concentration polonium-210 (pCi/liter)	Percent of AEC standard[a]	Average concentration plutonium-238 (pCi/liter)	Percent of AEC standard[b]	Average concentration tritium (nCi/liter)	Percent of AEC standard[c]
10	0.11±0.017	0.05	0.04±0.0034	0.002	2.7±0.10	0.27
11	.09± .015	.05	.11± .0056	.005	4.2± .13	.42
12	.13± .018	.07	.01± .0017	.001	2.5± .10	.25
13	.05± .011	.03	.05± .0037	.003	1.8± .08	.18
14	.11± .017	.05	.07± .0045	.003	8.6± .18	.86
15	.11± .017	.05	.10± .0053	.005	6.3± .15	.63
16	.13± .018	.07	.05± .0037	.003	3.1± .11	.31
17	.22± .023	.11	.21± .0077	.010	7.1± .16	.71

[a] AEC standard for polonium-210 in water is 200 pCi/liter. Lowest detectable limit for polonium-210 in water is 0.03 pCi/liter.
[b] AEC standard for plutonium-238 in water is 2000 pCi/liter. Lowest detectable limit for plutonium-238 in water is 0.04 pCi/liter.
[c] AEC standard for tritium in water is 1000 nCi/liter. Lowest detectable limit for tritium in water is 0.4 nCi/liter.

ured at these locations were less than 0.9 percent of the AEC standard. These results are presented in table 18.

Drinking water from communities in the surrounding area is sampled quarterly. These communities are shown in figure 1. A sample of approximately 4 liters is collected and analyzed for polonium–210, plutonium–238, and tritium oxide. The concentrations of polonium–210, plutonium–238, and tritium oxide were found to be less than 0.05 percent, 0.01 percent, and 2 percent of their AEC standards, respectively. The results of the community drinking water sampling program are summarized in table 19.

Food and vegetation

Various locally grown food and vegetation samples are collected from the surrounding area. The samples collected include milk, eggs, garden vegetables, grass, and aquatic life. The intent of this portion of the environmental monitoring program is to determine if there is any uptake and concentration of radionuclides by plant or animal life. The polonium–210 and plutonium–238 content of the foodstuff and vegetation samples is determined by slowly evaporating the sample to dryness and then proceeding with the same techniques used for

Table 19. Summary of community drinking water, Mound Laboratory environs, 1971

Location	Average concentration polonium–210 (pCi/liter)	Percent of AEC standard[a]	Average concentration plutonium–238 (pCi/liter)	Percent of AEC standard[b]	Average concentration tritium (nCi/liter)	Percent of AEC standard[c]
Bellbrook	<0.02±0.007	<0.01	0.02±0.008	0.001	1.3±0.034	0.13
Camden	<.02± .007	<.01	.05± .012	.003	.9± .028	.09
Centerville	<.02± .007	<.01	.04± .011	.002	1.5± .037	.15
Dayton	.05± .011	.03	.02± .008	.001	.3± .016	.03
Eaton	.04± .010	.02	.02± .008	.001	1.8± .040	.18
Franklin	.03± .008	.01	.02± .008	.001	1.1± .031	.11
Germantown	<.02± .007	<.01	.04± .011	.002	1.9± .041	.19
Kettering	<.02± .007	<.01	.02± .008	.001	.6± .023	.06
Lebanon	<.02± .007	<.01	.04± .011	.002	.3± .016	.03
Mason	<.02± .007	<.01	.02± .008	.001	<.3± .016	<.03
Miamisburg	.04± .010	.02	.25± .028	.013	19.7± .133	1.97
Middletown	<.02± .007	<.01	.02± .008	.001	1.0± .030	.10
Moraine	<.02± .007	<.01	NA		2.8± .050	.28
Springboro	<.02± .007	<.01	NA		2.8± .050	.28
Waynesville	<.02± .007	<.01	NA		4.3± .062	.43
West Carrollton	.03± .008	.01	.02± .008	.001	1.0± .030	.10

[a] The applicable AEC radiation protection standard for polonium–210 in water is 200 pCi/liter. Lowest detectable limit for polonium–210 in drinking water is 0.017 pCi/liter.
[b] The applicable AEC radiation protection standard for plutonium–238 in water is 2 000 pCi/liter. Lowest detectable limit for plutonium–238 in drinking water is 0.018 pCi/liter.
[c] The applicable AEC radiation protection standard for tritium in water is 1 000 nCi/liter. Lowest detectable limit for tritium oxide is 0.26 nCi/liter.
NA, no analysis.

Table 20. Summary of foodstuffs and vegetation analysis for 1971 Mound Laboratory environs

Type of sample	Average concentration polonium–210 (fCi/g)	Percent of AEC standard[a]	Average concentration plutonium-238 (fCi/g)	Percent of AEC standard[b]	Average concentration tritium (pCi/g)	Percent of AEC standard[c]
Milk	2.79	1.4	0.14	0.007	2.4	0.24
Eggs	NA		.31	.015	NA	
Vegetables	.78	.39	.31	.015	NA	
Grass	14.62	7.3	1.65	.083	NA	
Aquatic life	15.40	7.7	2.4	.12	NA	

[a] The applicable AEC radiation protection standard for plutonium–210 is 200 fCi/g.
[b] The applicable AEC radiation protection standard for plutonium–238 is 2000 fCi/g.
[c] The applicable AEC radiation protection standard for tritium is 1000 pCi/g.
NA, no analysis.

polonium–210 and plutonium–238 analyses of air samples. These samples are analyzed for tritium oxide by distilling the water fraction from an aliquot of the entire sample. The tritium content of the distillate is then determined in the same manner as the water samples previously discussed in this report. The results of the foodstuff and vegetation analyses are summarized in table 20. The concentration is given in terms of the sample weight before evaporation to dryness. The only foodstuff samples analyzed for tritium are milk. Rosenthal and Stewart (*3*) in their study on tritium transfer in simple aquatic food chains concluded that equilibrium between tritium in aquatic life and its environment is rapid and that a biological sink does not exist. Therefore, if the environment, i.e., air and water, were monitored, the levels found there would be indicative of the levels present in the plant and animal life growing therein. However, in addition to monitoring air and water for tritium, milk also is analyzed for tritium content since it is consumed in relatively large quantities by young children and babies. The vegetables analyzed included green beans, onions, corn, and tomatoes. The samples of aquatic life analyzed included only the edible fleshy portions. There appears to be a very small amount of polonium–210 in the aquatic life samples. Since the foodstuff sampling program has been in operation for only slightly more than a year and polonium–210 does appear naturally in the earth's crust, no conclusions can be drawn. More data must be accumulated before any conclusion can be reached as to the

source of the polonium–210 found in these types of samples. No other indication has been found that there is any significant uptake and concentration by plant or animal life of the three radionuclides handled at Mound Laboratory.

Soil and silt

Two types of soil samples from areas surrounding the laboratory have been analyzed for plutonium–238. One type of sample is used to evaluate the resuspendible amounts of plutonium–238 in the soil surrounding Mound Laboratory. Surface scrapings (approximately ⅛ inch deep) of undisturbed soil were collected for this evaluation. Surface scraping samples were taken from 20 sectors surrounding Mound Laboratory to a distance of 10 miles. These sectors are shown in figure 3. In addition, surface scrapings were taken 50 miles northeast, southwest, and northwest of the laboratory to serve as background control samples. Twenty-five scrapings are composited to form a sample for each sector. Soil samples are digested with an acid mixture to extract the plutonium. The solution is then passed over in ion exchange column specific for plutonium and analyzed in the same manner as the particulate air samples. This leach method has been compared with a fusion method for soil analysis (*4*), and good agreement was obtained. The leach method was chosen for the soil analysis because larger samples, which minimize sampling and aliquoting errors and increase sensitivity, can be handled with this method.

The results of the soil surface scraping study

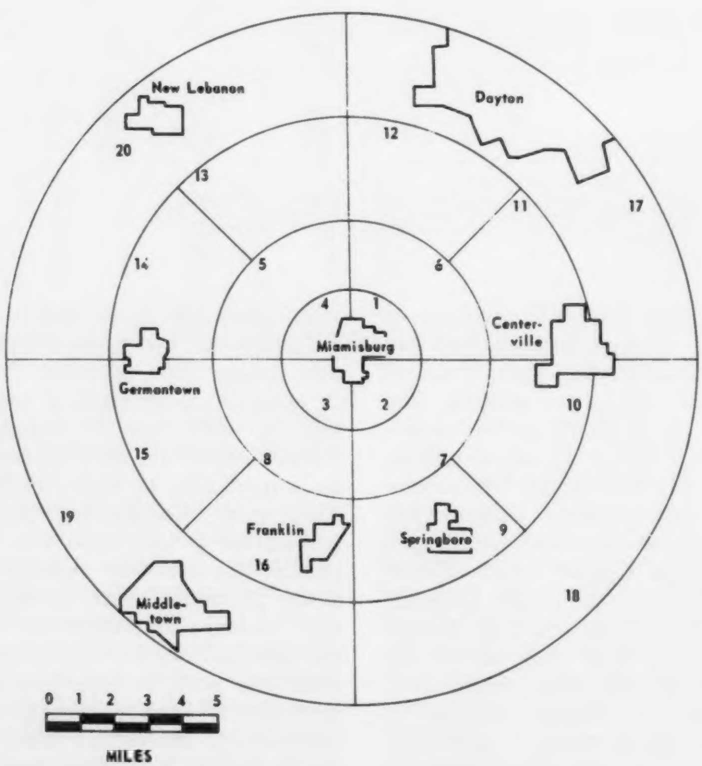

Figure 3. Soil sampling sectors, Mound Laboratory

Table 21. Resuspendible plutonium-238 levels determined from 1/8 inch soil surface scrapings, Mound Laboratory environs, January-December 1971

Sector	Plutonium-238 (dpm/cm^2)[a]
1	0.118 ±0.0065
2	.013 ± .0021
3	.174 ± .0078
4	.025 ± .0029
5	.003 ± .0010
6	.008 ± .0017
7	.004 ± .0012
8	.006 ± .0015
9	.003 ± .0010
10	.003 ± .0010
11	.001 ± .0005
12	.002 ± .0008
13	.004 ± .0012
14	.004 ± .0012
15	.003 ± .0010
16	.037 ± .0036
17	.004 ± .0012
18	.003 ± .0010
19	.003 ± .0010
20	.001 ± .0005
50 miles -NE[b]	.002 ± .0008
50 miles -SE[b]	.002 ± .0008
50 miles -SW[b]	.003 ± .0010
50 miles -NW[b]	.001 ± .0005
Reagent blanks	<0.001 − 0.003

[a] dpm/cm^2 = disintegration per minute per square centimeter of sample surface.
[b] Mound Laboratory background control data scrapings were taken at 50 miles.
[c] Lowest detectable limit for plutonium-238 in soil surface scrapings is 0.0004 dpm/cm^2.

for 1971 are shown in table 21. The highest concentration of plutonium-238 found in 1971 was approximately 2 percent of the most restrictive levels suggested by Kathren (*5*) for urban areas.

The second type of sample is used to determine the inventory amounts of plutonium-238 in the soil surrounding Mound Laboratory. A 3.5-inch diameter core of soil approximately 1.5 inches deep is taken for this determination. The site selection and sampling techniques used in core sampling basically were those suggested by the criteria given for "Soil Sampling for Plutonium Analysis" as distributed by the AEC Division of Operational Safety. Core samples were collected from various locations within approximately 1 mile from the laboratory. Five cores were collected from a 20-foot square area at each location and composited to form one core sample. Additional core samples for background control data were taken from locations 50 miles from the laboratory. The background control core samples consisted of 20 cores, 4 cores from each of 5 locations. The results of the core sampling program are summarized in table 22. The sectors referred to are those shown on figure 3. No standards have been established for radioactive species in soil. Additional sample analyses are necessary before a total inventory can be calculated and these are continuing as part of the Mound Laboratory's comprehensive Environmental Control Program.

Silt samples are collected quarterly from four locations on the Great Miami River. These samples are taken at four of the same locations that water samples are taken from and are identified by the same number shown in figure 2. Additional silt samples are collected annually from the same surface water locations which are sampled monthly. The silt samples are analyzed in the same manner as the soil samples. The results of Great Miami River silt sampling for 1971 are summarized in table 23.

Table 22. Plutonium-238 results in soil samples at core locations Mound Laboratory environs, January-December 1971

Sector	Plutonium-238[a]	
	(dpm/g)[b]	(dpm/cm^2)[c]
1	4.68 ±0.03	16.31 ±0.10
2	2.19 ± .02	6.31 ± .06
3	.07 ± .004	.30 ± .01
4	.12 ± .005	.46 ± .02
Irwin, Ohio (Northeast–50 miles)	.005 ± .001	.016 ± .003
Sardinia, Ohio (Southeast–50 miles)	.005 ± .001	.014 ± .003
Aurora, Indiana (Southwest–50 miles)	.003 ± .001	.008 ± .002
Winchester Indiana (Northwest–50 miles)	.003 ± .001	.010 ± .002
Reagent blanks	<.001 ± .001	.002 ± .001

[a] The levels of plutonium in soil as a result of nuclear testing fallout reported by Health and Safety Laboratory for the southern Ohio area range from 0.248 to 0.416 dpm/cm^2.
[b] dpm/g = disintegration per minute per gram of sample.
[c] dpm/cm^2 = disintegration per minute per square centimeter of sample surface.
Lowest detectable limit for plutonium-238 in soil core samples is 0.0003 dpm/g or 0.0008 dpm/cm^2.

Table 23. Summary of Great Miami River silt samples for 1971, Mound Laboratory environs

Location	Plutonium–238 (dpm/g)[a]
2	0.431 ±0.021
4	.408 ±0.021
6	.947 ±0.032
7	.865 ±0.030

[a] dpm/g = disintegration per minute per gram of sample.
Lowest detectable limit for plutonium–238 in silt samples is 0.001 dpm/g.

The results of the silt sampling from the area ponds are summarized in table 24. There appears to be a very slight accumulation of plutonium–238 in river silt from the very small amounts of plutonium–238 which are discharged to the river. However, as mentioned previously, there does not appear to be any reentrainment of plutonium–238 by plant or animal life in the river nor by the river itself. No significant accumulation is indicated, however, by the pond silt data. There are no standards for radioactive species in silt.

Table 24. Summary of pond silt samples for 1971 Mound Laboratory environs

Location	Plutonium–238 (dpm/g)[a]
10	0.017 ±0.004
11	.027 ± .005
12	.023 ± .005
13	.062 ± .008
14	.017 ± .004
15	.011 ± .003
16	.012 ± .004
17	.038 ± .006

[a] dpm/g = disintegration per minute per gram of sample.
Lowest detectable limit for plutonium–238 in silt samples is 0.001 dpm/g.

Summary

The average concentrations of polonium–210, plutonium–238, and tritium detected in the environment surrounding Mound Laboratory, Miamisburg, Ohio, are presented for January–December 1971. The average concentrations of these radioisotopes were well within the standards adopted by the Atomic Energy Commission.

Atmospheric monitoring for radioactive species found the highest average concentrations of plutonium and tritium in air during 1971 to be 1 percent and 4 percent of their respective AEC standards. These concentrations are 10 percent and 26 percent lower, respectively, than those detected during 1970. The average concentrations of polonium in air detected during 1971 were approximately 0.2 percent of the AEC standard which is approximately the same as detected during 1970.

Water monitoring for radioactive species found the highest average concentration of plutonium at any of the water sampling locations during 1971 to be only 0.2 percent of the AEC standard which is 40 percent of the highest average concentration reported during 1970. The highest average concentrations of polonium and tritium in water during 1971 were 1.8 percent and 2.8 percent of their respective AEC standards. These concentrations are approximately the same as reported during 1970.

Additionally, data concerning radioactive species in surface water, community drinking water, foodstuffs and silt are presented for the first time. No significant uptake of radioactive species from air or water by plant or animal life has been observed. No reentrainment of radioactive species from soil or silt is indicated at this time. The highest level of plutonium–238 found during 1971 in soil surface scrapings was approximately 2 percent of the most restrictive levels suggested for urban areas. Soil core sample analyses will continue to establish a plutonium soil inventory as part of the total program to assess the impact of the laboratory's operations on the environment.

These data indicate that the operation of the laboratory has had a negligible effect on the environment.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1970	March 1973

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(*2*) U.S. DEPARTMENT OF HEALTH, EDUCATION, and WELFARE. Report for consultation on the metropolitan Dayton intrastate air quality control region. Consumer Protection and Environmental Health Service, National Air Pollution Control Administration (September 1969), p. 11.

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(*5*) KATHREN, R. L. Towards interim acceptable surface contamination levels for environmental PuO_2, BNWL-SA-1510. Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Wash. (March 14, 1968), p. 10.

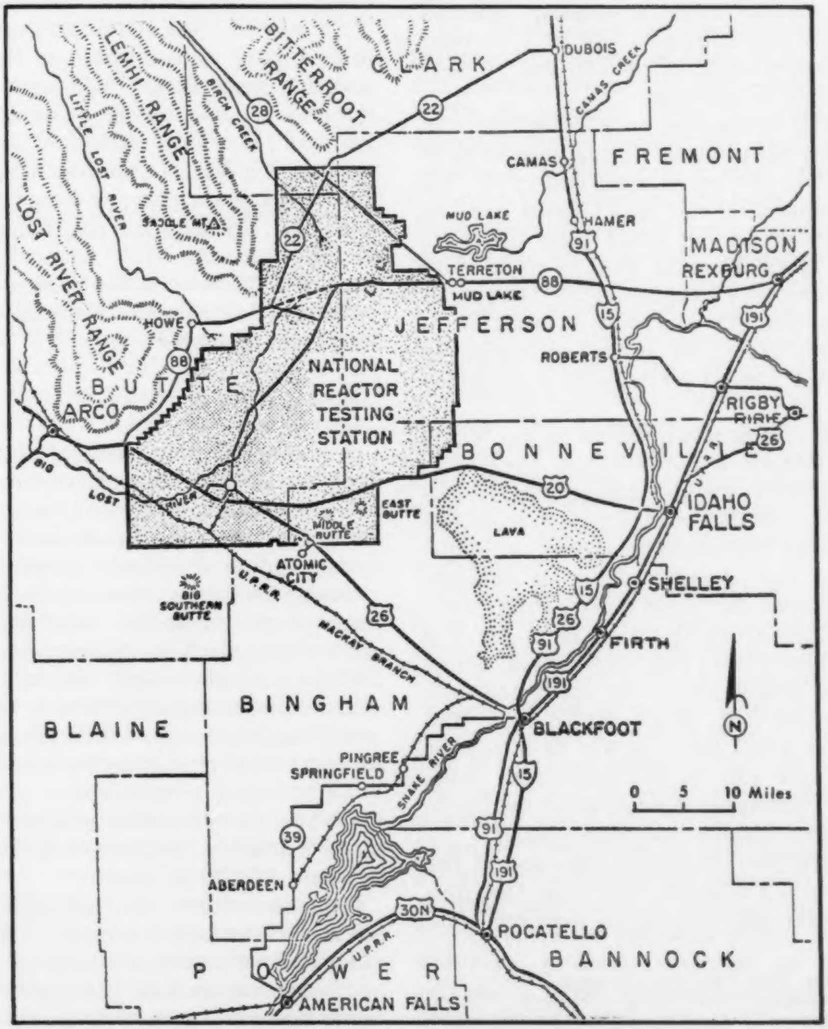

Figure 4. National Reactor Testing Station environs

2. National Reactor Testing Station[3] January–December 1971

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) was established in 1949 by the U.S. Atomic Energy Commission (AEC) to promote reactor development by building, testing, and operating various types of nuclear reactors, allied plants, and equipment. By 1971, 49 reactors had been built at the NRTS and 16 were still operating or operable.

The NRTS is situated on a desert plain in southeastern Idaho at an average elevation of 4865 feet. The station is comprised of 571 800 acres of sagebrush and basalt fields and the boundary stretches 39 miles from north to south and about 36 miles wide in its broader southern part. The nearest NRTS boundaries are 29 miles west of Idaho Falls, 32 miles northwest of Blackfoot, 50 miles northwest of Pocatello, and 7 miles southeast of Arco, Idaho (figure 4).

Although annual precipitation in the NRTS area has averaged only 8.5 inches, underlying the desert plain is a huge natural underground reservoir of water in the basaltic lava rock. The lateral flow of this water is about one billion gallons per day. Aquifer water is supplied principally from the North Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and sink into the porous soils of the NRTS area. The underground water seeps slowly at a rate of 10–20 feet per day to the south and west, emerging in numerous springs along the Snake River between Milner and Bliss, Idaho.

Major programs currently underway at the NRTS fall into five major categories. One program provides test irradiation services from the two operating high-flux test reactors, the ETR and ATR. Another program operates the Idaho Chemical Processing Plant (ICPP) for recovery of uranium from highly enriched spent fuels. A third major program is that of light-water-cooled reactor safety testing and research. The Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF) are the important projects in the reactor safety program. Other significant programs include the operation of the Experimental Breeder Reactor II (EBR–II) by Argonne National Laboratory and the operation of the Naval Reactor Facility (NRF).

Because of these activities, small amounts of radioactivity were released to the atmosphere and the Snake River Plain aquifer. In its environmental monitoring program, the Health Services Laboratory (HSL) of the AEC measured the levels of radioactivity in air and ground water samples and measured the gamma radiation exposure at onsite locations, communities near the NRTS boundary, and distant background locations. The concentration of suspended airborne particulates and dust fall rates also were measured.

Air monitoring

Air samplers were operated continuously and drew air through sets of filters for weekly periods. A membrane prefilter (Gelman Model AN–8000) for collection of particulates was followed by an in-line activated charcoal-impregnated cellulose fiber filter (Gelman Model AC–1) for removal of radioiodine from the air stream. An average air flow of approximately 1 cubic foot per minute (cfm) was maintained. Air samplers were located onsite, in the small communities close to the NRTS perimeter, and at distant background sites (figure 5). These locations provided comprehensive surveillance of atmospheric radioactivity and theoretically made it possible to differentiate worldwide fallout from NRTS releases.

The filters were analyzed 5 days after the end of each sampling period to allow for decay of short-lived natural radioactivity. Gross alpha and beta analyses were performed on the membrane filters and gross beta analyses alone were performed on the charcoal filters. Activity de-

[3] Summarized from "National Reactor Testing Station Environmental Monitoring Program Report, January–December 1971," U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory.

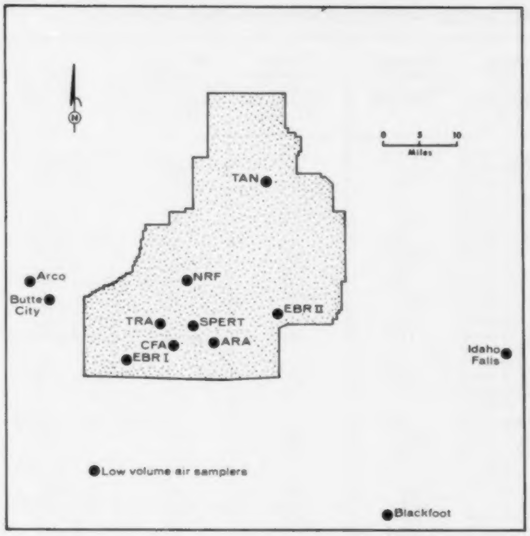

Figure 5. Onsite and offsite air sampling locations, National Reactor Testing Station

tected on the charcoal filters was assumed to be iodine–131. Gross alpha activity was determined by a technique reported by Hallden and Harley (*6*). Using this method an alpha-sensitive phosphor disc was placed in direct contact with the filter and counted with a low-noise photomultiplier tube. For gross beta analyses, the filters were mounted on a ringed planchet and counted in a low background beta counter. At the end of each calendar quarter, the particulate filters from selected locations were composited and the concentrations of gamma-emitting radionuclides determined by gamma spectrometry. A strontium–90 analysis also was performed on the quarterly composites. Each membrane filter was dried and weighed before and after use to determine the average airborne particulate concentrations during the sampling period.

Onsite air samples were collected at locations close to the sources of released radioactivity and were expected to have the highest concentrations. Background samples were collected at Idaho Falls, Blackfoot, and Pocatello. These locations were sufficiently remote to ensure that any radioactivity detected was due to natural background or sources other than NRTS operations. Levels of radioactivity in onsite and boundary community (Arco, Butte City, Howe, and Mud Lake) air samples were compared to levels in the background samples. If the radioactivity levels were found to be significantly higher than background, the net amount above background was assumed to be radioactivity introduced to the environment from NRTS operations. The net concentrations of radioactivity then were compared to the AEC standards set forth in the U.S. Atomic Energy Commission's Manual Chapter 0524 (AECM 0524). The air sampling data are presented in table 25.

The gross alpha air concentrations at the background locations of Idaho Falls, Blackfoot, and Pocatello were not representative of the NRTS background levels. This was due to higher airborne concentrations of naturally occurring radioactivity in the upper Snake River Valley. Therefore, the onsite gross alpha concentrations and the gross alpha concentrations at the NRTS boundary communities were not compared to an average background concentration. However, if measurable onsite releases of alpha activity were occurring, it would have been expected that the gross alpha concentrations at onsite locations would be higher than at the communities near the NRTS boundary. This pattern was not observed and indicates the gross alpha concentrations measured at the NRTS and boundary community locations were the result of natural background radioactivity.

All the gross beta (iodine–131) concentrations determined from the charcoal filters were near or below the detection limit of the analysis. For 1971, the average gross beta concentration of particulates at onsite locations was 0.65 pCi/m^3 and the highest individual average was 0.82 pCi/m^3, occurring at the CFA location. The yearly average background gross beta concentration was 0.53 pCi/m^3. The difference between the average onsite and offsite gross beta concentration was largely the result of releases of small quantities of radioactivity from the Idaho Chemical Processing Plant. Fission and activation products identified on the onsite particulate filters were cerium-praseodymium–144, antimony–125, cesium–134, cesium–137, ruthenium-rhodium–106, ruthenium–103, zir-

Table 25. Radioactivity in air, National Reactor Testing Station, January-December 1971

Sampling locations	Number of samples	Type of analysis and filter	Minimum detectable concentration (fCi/m³)	Maximum single sample concentration (fCi/m³)	Average sample concentration (fCi/m³)	Average background concentration, if applicable (fCi/m³)	Maximum average net concentration (fCi/m³)	AEC standard (fCi/m³)
Onsite (8 locations)	416	Gross α —Membrane	1	19	1.7	—	1.7	6 000
		Gross β —Membrane	10	3 200	650	530	120	[a] 30 000
		Gross β —Charcoal	10	270	<10	<10	<10	9×10^6
EBR-I (onsite)	52	^{144}Ce-Pr —Membrane	—	—	160	<140	<160	6×10^6
		^{125}Sb —Membrane	—	—	<22	<7.0	<22	3×10^7
		^{134}Cs —Membrane	—	—	<8.9	<1.4	<8.9	4×10^7
		^{137}Cs —Membrane	—	—	<35	<9.6	<35	1×10^7
		^{106}Ru-Rh—Membrane	—	—	43	<28	<43	6×10^6
		^{103}Ru —Membrane	—	—	9.8	<14	<9.8	8×10^7
		^{95}Zr —Membrane	—	—	<47	<35	<47	3×10^7
		^{95}Nb —Membrane	—	—	71	57	14	1×10^8
		^{141}Ce —Membrane	—	—	<8.3	<11	<8.3	2×10^8
		^{90}Sr —Membrane	—	—	18	<4.7	<18	6×10^6
Arco (offsite)	52	Gross α —Membrane	1	4.7	1.7	—	1.7	20
		Gross β —Membrane	10	1 600	500	530	—	[a] 1 000
		Gross β —Charcoal	10	36	<10	<10	<10	1×10^5
Howe (offsite)	52	Gross α —Membrane	1	4.5	1.9	<	1.9	20
		Gross β —Membrane	10	1 700	630	530	100	[a] 1 000
		Gross β —Charcoal	10	50	<10	<10	<10	1×10^5
Butte City (offsite)	52	Gross α —Membrane	1	3.3	1.5	—	1.5	20
		Gross β —Membrane	10	2 100	620	530	90	[a] 1 000
		Gross β —Charcoal	10	51	<10	<10	<10	1×10^5
		^{144}Ce-Pr —Membrane	—	—	110	<140	<110	2×10^5
		^{125}Sb —Membrane	—	—	<8.4	<7.0	<8.4	9×10^5
		^{103}Ru —Membrane	—	—	11	<14	<11	3×10^7
		^{106}Ru-Rh—Membrane	—	—	<24	<28	<24	2×10^5
		^{134}Cs —Membrane	—	—	<2.8	<1.4	<2.8	4×10^5
		^{137}Cs —Membrane	—	—	9.7	<9.6	<9.7	5×10^5
		^{95}Zr —Membrane	—	—	<36	<35	<36	1×10^6
		^{95}Nb —Membrane	—	—	63	57	6	3×10^6
		^{141}Ce —Membrane	—	—	<7.7	<11	<7.7	5×10^6
		^{90}Sr —Membrane	—	—	4.7	<4.7	<4.7	30 000
Mud Lake (offsite)	52	Gross α —Membrane	1	3.3	1.5	—	1.5	20
		Gross β —Membrane	10	1 900	620	530	90	[a] 1 000
		Gross β —Charcoal	10	26	<10	<10	<10	1×10^5
		^{144}Ce-Pr —Membrane	—	—	<180	<140	<180	2×10^5
		^{125}Sb —Membrane	—	—	<16	<7.0	<16	9×10^5
		^{103}Ru —Membrane	—	—	<17	<14	<17	3×10^6
		^{106}Ru-Rh—Membrane	—	—	<42	<28	<42	2×10^5
		^{114}Cs —Membrane	—	—	<6.4	<1.4	<6.4	4×10^5
		^{137}Cs —Membrane	—	—	15	<9.6	<15	5×10^5
		^{95}Zr —Membrane	—	—	<49	<35	<49	1×10^6
		^{95}Nb —Membrane	—	—	74	57	17	3×10^6
		^{141}Ce —Membrane	—	—	<11	<11	<11	5×10^6
		^{90}Sr —Membrane	—	—	13	<4.7	<13	30 000

[a] Assumes actinium-227 not present.

conium–95, niobium–95, cerium–141, and strontium–90. The same radionuclides were also identified on the background air filters, though generally in smaller concentrations. None of the concentrations of radionuclides identified on the onsite filters exceeded 0.002 percent of the corresponding AEC standards.

The air concentrations are mainly due to worldwide nuclear test fallout activity. An increase in the onsite and boundary community average above worldwide fallout levels such as occurred late in 1970 and the first half of 1971 are the result of atmospheric releases from the NRTS.

At the boundary community air sampling locations of Butte City, Mud Lake, Howe, and the offsite sampling locations closest to the NRTS, it was found that the average gross beta concentrations were slightly above the worldwide fallout level. The highest offsite yearly average net gross beta concentration of 0.10 pCi/m³ which occurred at Howe was only 10 percent of the appropriate concentration guide. The same radionuclides identified in the onsite samples were also found at the boundary community locations, although generally in smaller concentrations. None of the concentrations of radionuclides identified on the boundary community filters exceeded 0.09 percent of the concentration guide.

Water monitoring

Water samples were collected from onsite and

Table 26. Radioactivity in well water samples, National Reactor Testing Station, January-December 1971

Sampling location	Number of samples	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration [a] (pCi/liter)	Average background concentration (pCi/liter)	Maximum average net concentration (pCi/liter)
EBR-1 (1 well)	8	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
CFA (2 wells)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	[c]140	[c]2	[c]99	(b)	[c]99
TRA (3 wells)	104	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	10	5	<5.1	(b)	<5.1
		Tritium	(b)	[c]2	(b)	(b)	(b)
CPP (2 wells)	45	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	72	5	<8.7	(b)	<8.7
		Tritium	[c]9.0	[c]2	[c]<4.7	(b)	[c]<4.7
		Strontium-90	28	1	4.6	—	4.6
NRF (3 wells)	63	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	6.8	5	<5.0	(b)	<5.0
		Tritium	(b)	[c]2	(b)	(b)	(b)
TAN (6 wells)	129	Gross alpha	4	3	<3.0	(b)	<3.0
		Gross beta	12	5	<5.1	(b)	<5.1
		Tritium	(b)	[c]2	(b)	(b)	(b)
SPERT-PBF (2 wells)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	8	5	<5.2	(b)	<5.2
		Tritium	(b)	[c]2	(b)	(b)	(b)
ARA (2 wells)	52	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
EDF (1 well)	9	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
EBR-II (2 wells)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
Fire Station No. 2 (1 well)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)

[a] AEC standards—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3 000 nCi/liter, and strontium-90, 300 pCi/liter.
[b] Below detection limit.
[c] Concentration of tritium in nCi/liter.

Table 27. Radioactivity in offsite drinking water and surface water samples, National Reactor Testing Station January-December 1971

Sampling location	Number of samples	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration [a] (pCi/liter)	Average background concentration, if applicable (pCi/liter)	Maximum average net concentration (pCi/liter)
Drinking water, from Arco, Carey, Aberdeen, Dietrich, Atomic City, and Minidoka	12	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
Snake River at Bliss, Idaho	2	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)

[a] AEC standard—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3 000 nCi/liter.
[b] Below detection limits.
[c] Concentration of tritium in nCi/liter.

offsite drinking water production wells and from the Snake River. Offsite and onsite water sampling locations can be seen in figures 6 and 7, respectively. All offsite samples were collected biannually; onsite samples were generally collected every 2 weeks. Gross alpha, gross beta, and tritium analyses routinely were performed on the water samples. For gross alpha analysis, an aliquot of the sample was evaporated on a stainless-steel planchet and counted with a scintillation counter using a technique similar to that described for the gross alpha analysis for the air filters. Another aliquot was evaporated and counted for gross beta activity in a low background beta counter. Tritium concentrations were determined with a Beckman Liquid Scintillation System. Water sampling data are presented in tables 26 and 27. Samples collected from Mud Lake, Monteview, Reno Ranch, Idaho Falls, and Roberts (all upgradient

in the aquifer from the NRTS) were used to determine the background concentrations of radioactivity.

None of the offsite water samples collected during 1971 contained concentrations of radioactivity above the detection limits of the analyses. Only a few onsite samples contained gross alpha concentrations above the detection limit of 3 pCi/liter. Of the wells used for drinking purposes, the highest average beta concentration, 72 pCi/liter, was found in well number 2 at the Idaho Chemical Processing Plant. The 1971 average strontium–90 concentration at the ICPP was 4.6 pCi/liter. This strontium–90 concentration is less than 2 percent of the AECM 0524 standard. The highest 1971 average tritium concentration, 99 nCi/liter, was found at the Central Facilities Area (CFA) and was 3.3 percent of the AECM 0524 standard.

Food monitoring

Milk was the main foodstuff sampled. A composite grade A sample was collected from farm areas to the north and south of Idaho Falls each week. Monthly grade B milk samples were collected from dairies and individual farms in rural areas surrounding the NRTS. Analysis by gamma spectrometry for iodine–131 and cesium–137 was performed on all milk samples. Biannually the samples were analyzed for strontium–90. Wheat samples were collected from individual farms and grain elevators during the fall harvest and analyzed for gamma-emitting radionuclides by gamma spectrometry and for strontium–90. See figure 6 for the milk and wheat sampling locations.

All milk sampling results summarized in table 28 were compared to standards recommended by the Federal Radiation Council, since the AECM 0524 does not list concentration guides for milk. During 1971, the concentrations of iodine–131 and cesium–137 in milk were near or below the detection limits of the analysis. Strontium–90 concentrations in milk were less than 3 percent of the standard and were attributed to worldwide fallout, not NRTS operations. Only strontium–90 activity was detected in the wheat samples with the hull containing 90 percent of the total. This means only 10 percent of the activity will remain after the wheat is processed for use in food products. The strontium–90 in wheat is also attributed to worldwide fallout. Wheat sampling results are shown in table 29.

Table 28. Radionuclide concentrations in milk, National Reactor Testing Station January-December 1971

Location and sampling frequency	Analysis	Maximum single sample concentration (pCi/liter)	Average concentration[a] (pCi/liter)
Idaho Falls (weekly)	Iodine–131	21	<20
	Cesium–137	34	<30
	Strontium–90[b]	3.2	2.7
Minidoka (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	2.9	<2.4
Dietrich (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	5.5	4.2
Carey (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	6	4.2
Mud Lake (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	3.3	2.5
Reno Ranch (monthly)	Iodine–131	(c)	(c)
	Cesium–137	31	30
	Strontium–90[b]	2.9	2.4
Tabor (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	1.6	1.5
Howe (monthly)	Iodine–131	23	<20
	Cesium–137	(c)	(c)
	Strontium–90[b]	3.8	3.1
Arco (monthly)	Iodine–131	22	<20
	Cesium–137	(c)	(c)
	Strontium–90[b]	5.2	3.7
Firth and New Sweden (near Idaho Falls) (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	4.2	2.9
Lake and Riverside (Tabor-Blackfoot-Aberdeen area) (monthly)	Iodine–131	(c)	(c)
	Cesium–137	(c)	(c)
	Strontium–90[b]	4.0	3.3

[a] Federal Radiation Council standard: iodine–131, 100 pCi/liter; cesium–137, 3600 pCi/liter; strontium–90, 200 pCi/liter. Minimum detectable concentration: iodine–131, 20 pCi/liter; cesium–137, 30 pCi/liter; strontium–90, 1 pCi/liter.
[b] Only two samples during the year analyzed for strontium-90 activity.
[c] Below detection limits.

Table 29. Strontium–90 concentrations in wheat NRTS, January-December 1971

Sampling location	Strontium–90 concentration (pCi/g)
Monteview	0.014
Idaho Falls	.020
Blackfoot	.019
American Falls	.013
Minidoka	.019
Dietrich	.010
Carey	.017
Arco	.011

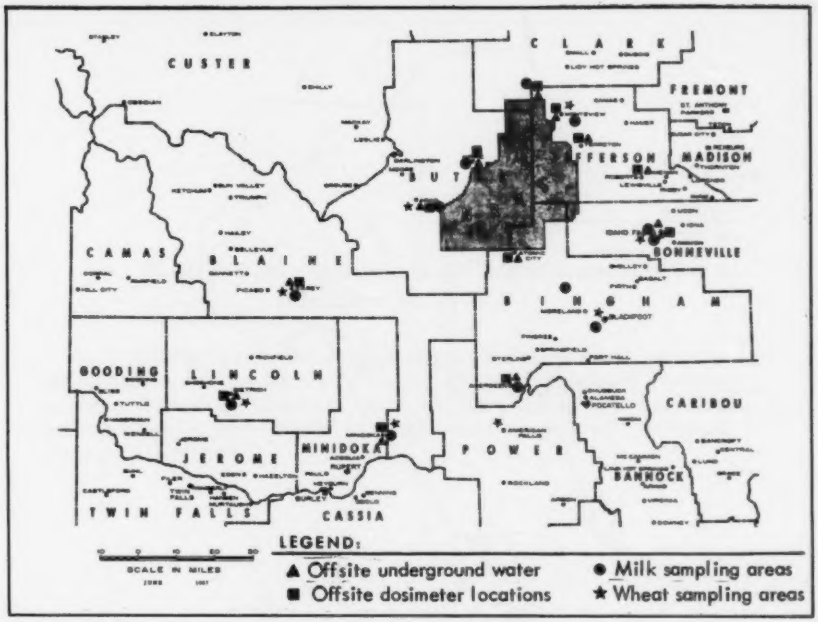

Figure 6. Environmental monitoring program, National Reactor Testing Station

Gamma radiation exposure

Environmental gamma radiation exposures were measured with thermoluminescent dosimeters (TLD's) placed at background and NRTS boundary community locations. Exposures at the distant locations of Idaho Falls, Blackfoot, Dietrich, Carey, Aberdeen, and Minidoka were considered background levels. Measurements of boundary community exposures were made at Atomic City, Howe, Arco, Butte City, Mud Lake, and Roberts. There was no evidence to suggest that any of the exposures at the NRTS boundary communities were different from background or were the result of NRTS activities.

Summary

The results of the air monitoring program for 1971 indicated that the increases in air concentrations offsite due to NRTS releases were indistinguishable from the natural radioactivity in air. When special techniques were used to measure the worldwide radioactive fallout (approximately 0.2 percent to 2 percent of the natural radioactivity in air) the sensitivity was high enough to indicate small releases of NRTS activity measurable above the worldwide fallout. The average increased exposure by airborne radioactivity just offsite was approximately 0.5 percent of the natural radon series and thoron series exposure in air. From identification of specific radionuclide concentrations none of the concentrations were greater than 0.09 percent of the appropriate standard as listed in the concentration guides of the U.S. Atomic Energy Commission's Manual Chapter 0524.

None of the offsite well water or surface water samples contained any gross alpha, gross beta, or tritium activity above the detection limits of the analyses. The fission product levels in milk were similar to those reported in *Radiation Data and Reports* for the region and the source is believed to be fallout from nuclear weapons and not NRTS operations. Wheat samples collected at harvest also contained small

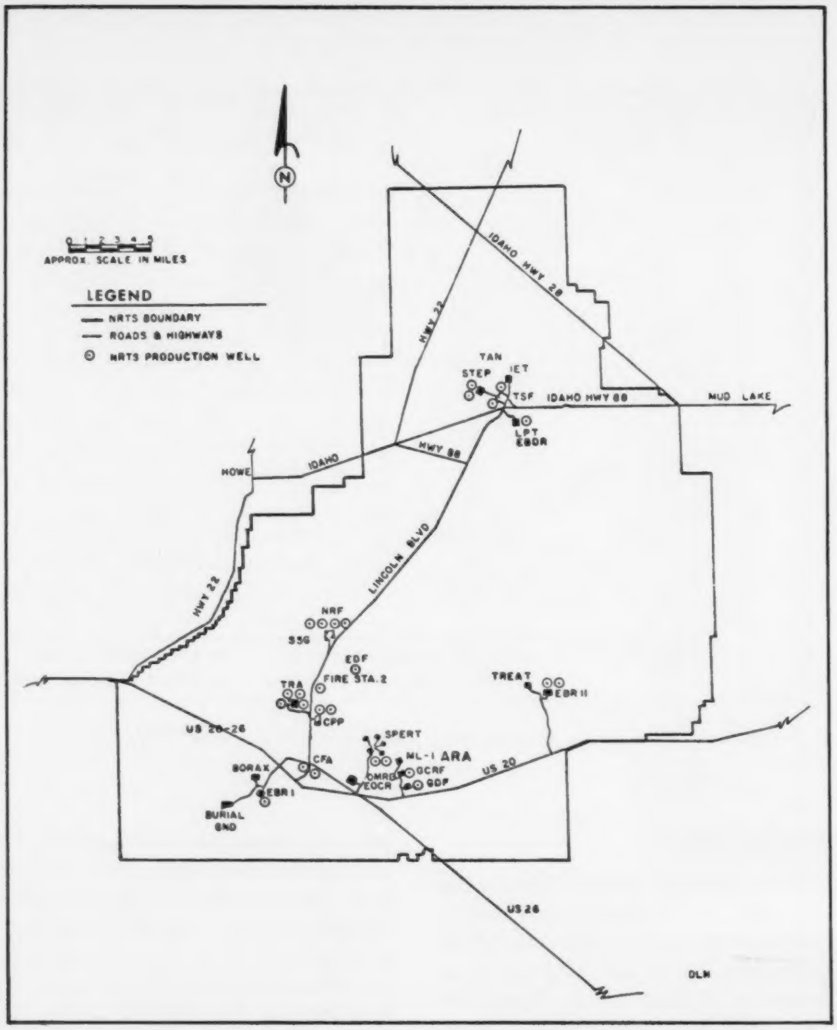

Figure 7. National Reactor Testing Station

amounts of strontium-90 from worldwide fallout.

Gamma radiation exposures were measured simultaneously at distant background locations and at communities near the NRTS boundary. There was no evidence that the exposures at the NRTS boundary communities were different from background.

REFERENCE

(6) HALLDEN and HARLEY. An improved alpha counting technique. Anal Chem 32:1861 (1960).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1970	December 1973

Nuclear Power Reactors in the United States
December 31, 1973

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

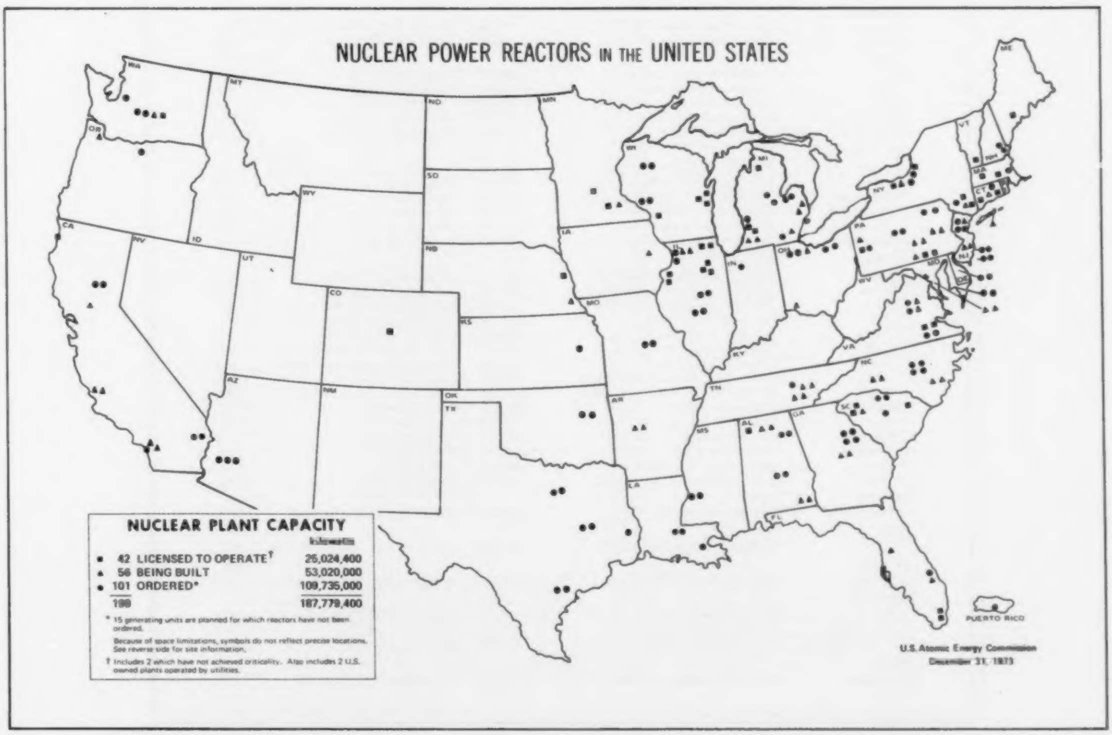

Figure 1. Nuclear power reactors in the United States, December 31, 1973

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1980
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1981
Scottsboro	Bellefonte Nuclear Plant: Unit 1	1,189,000	Tennessee Valley Authority	1979
Scottsboro	Bellefonte Nuclear Plant: Unit 2	1,189,000	Tennessee Valley Authority	1980
Wintersburg	–	1,270,000	Arizona Public Service	1981
Wintersburg	–	1,270,000	Arizona Public Service	1982
Wintersburg	–	1,270,000	Arizona Public Service	1984
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1974
Russellville	Arkansas Nuclear One: Unit 2	912,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1979
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1980
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,084,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,106,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	913,000	Sacramento Municipal Utility District	1974
*	–	1,128,000	Pacific Gas & Electric Co.	1981
*	–	1,128,000	Pacific Gas & Electric Co.	1982
Needles	Eastern Desert Plant: Unit 1	770,000	Southern California Edison Co.	1981
Needles	Eastern Desert Plant: Unit 2	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1974
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Summit	Summit Power Station: Unit 1	770,000	Delmarva Power & Light Co.	1980
Summit	Summit Power Station: Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1974
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1979
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1980
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1981
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 3	1,121,000	Georgia Power Co.	1982
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 4	1,121,000	Georgia Power Co.	1983
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle County Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1978
Seneca	LaSalle County Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1979
Bryon	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1980
Bryon	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1981
Braidwood	Braidwood: Unit 1	1,100,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,100,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant: Unit 1	955,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	955,000	Illinois Power Co.	1982
INDIANA				
Porter County	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1979
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	569,000	Iowa Electric Light and Power Co.	1974
KANSAS				
Burlington	Wolf Creek Generation Station: Unit 1	1,150,000	Kansas Gas & Electric–Kansas City P & L	1981
LOUISIANA				
Taft	Waterford Generating Station	1,113,000	Louisiana Power & Light Co.	1977
St. Francisville	River Bend Station: Unit 1	934,000	Gulf States Utilities Co.	1980
St. Francisville	River Bend Station: Unit 2	934,000	Gulf States Utilities Co.	1981
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972

Figure 1. Nuclear power reactors in the United States, December 31, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Nanjemoy	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Nanjemoy	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1980
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1965
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,172,000	Detroit Edison Co.	1981
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1976
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1980
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1979
St. Clair County	Greenwood: Unit 2	1,200,000	Detroit Edison Co.	1980
St. Clair County	Greenwood: Unit 3	1,200,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1982
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSOURI				
Fulton	–	1,150,000	Northern States Power Co.	1981
Fulton	–	1,150,000	Northern States Power Co.	1983
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station: Unit 1	1,290,000	Mississippi Power & Light Co.	1979
Port Gibson	Grand Gulf Nuclear Station: Unit 2	1,290,000	Mississippi Power & Light Co.	1981
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1974
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station: Unit 1	1,200,000	Public Service of N.H.	1979
Seabrook	Seabrook Nuclear Station: Unit 2	1,200,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1979
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1975
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1976
Salem	Hope Creek Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1981
Salem	Hope Creek Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1982
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
*	–	1,150,000	Public Service Electric and Gas, N.J.	1983
*	–	1,150,000	Public Service Electric and Gas, N.J.	1984
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R.E.Ginna Nuclear Power Plant: Unit 1	470,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
*		1,150,000	Long Island Lighting Co.	1981
Oswego	Sterling Nuclear: Unit 1	1,150,000	Rochester Gas & Electric Co.	1982
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1976
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1980
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1981
*	–	1,300,000	Duke Power Co.	1981
*	–	1,300,000	Duke Power Co.	1982
*	–	1,300,000	Duke Power Co.	1983
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 1	906,000	Toledo Edison-Cleveland El. Illum. Co.	1976
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 2	906,000	Toledo Edison-Cleveland El. Illum. Co.	1981
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 3	906,000	Toledo Edison-Cleveland El. Illum. Co.	1983
Perry	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Perry	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1977
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 2	1,000,000	Cincinnati Gas & Electric Co.	1982

Figure 1. Nuclear power reactors in the United States, December 31, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OKLAHOMA				
Inola	Black Fox Nuclear Station: Unit 1	950,000	Public Service of Oklahoma	1982
Inola	Black Fox Nuclear Station: Unit 2	950,000	Public Service of Oklahoma	1984
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman	–	1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1974
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1979
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1980
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1975
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1979
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1976
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
Fuller	Fulton Generating Station: Unit 1	1,140,000	Philadelphia Electric Co.	1981
Fuller	Fulton Generating Station: Unit 2	1,140,000	Philadelphia Electric Co.	1983
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1978
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
*	–	1,300,000	Duke Power Co.	1984
*	–	1,300,000	Duke Power Co.	1985
*	–	1,300,000	Duke Power Co.	1986
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1975
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1978
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Clinch River Breeder Reactor Plant	350,000	Project Management Corporation	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Jasper	Blue Hills: Unit 1	918,000	Gulf States Utilities	1980
Wallis	Allens Creek: Unit 1	1,150,000	Houston Lighting & Power Co.	1980
Wallis	Allens Creek: Unit 2	1,150,000	Houston Lighting & Power Co.	1982
Bay City	South Texas Project	1,250,000	Central Power & Light Co.	1980
Bay City	South Texas Project	1,250,000	Central Power & Light Co.	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1976
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Co.	1978
Gravel Neck	Surry Power Station: Unit 3	882,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	882,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,206,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
Satsop	WPPSS No. 3	1,242,000	Washington Public Power Supply System	1981
Sedro Woolley	Skagit Nuclear Project	1,200,000	Puget Sound Power & Light	1982
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1973
*	–	900,000	Wisconsin Electric Power Co.	1980
*	–	900,000	Wisconsin Electric Power Co.	1982
Durand	Tyrone Energy Park: Unit 1	1,150,000	Northern States Power Co.	1982
Durand	Tyrone Energy Park: Unit 2	1,150,000	Northern States Power Co.	1983
PUERTO RICO				
Puerta De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1979

* Site not selected.

*	–	1,128,000	Tennessee Valley Authority	1980
*	–	1,128,000	Tennessee Valley Authority	1981
*	–	1,128,000	Tennessee Valley Authority	1980
*	–	1,128,000	Tennessee Valley Authority	1981

Figure 1. Nuclear power reactors in the United States, December 31, 1973—continued

Reported Nuclear Detonations, February 1974

(Includes seismic signals presumably from foreign nuclear detonations)

There were no seismic signals recorded by the United States for February 1974.

The U.S. Atomic Energy Commission conducted an underground nuclear test at its Nevada Test Site on February 27, 1974. The test was in the yield range between 20 and 200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOLOGICAL SURVEILLANCE AROUND TURKEY POINT, 1970–1971. *Wallace Johnson* and *Jearold Eakins. Radiation Data and Reports, Vol. 15,* March 1973, pp. 105–115.

Prior to the operation of the Turkey Point Nuclear Power reactor environmental media were sampled and data are presented for 1970–71. Basic media investigated includes air, precipitation, soil, silt, and water, including sea water.

A number of media utilized as indicator organisms serve to investigate the behavior of radionuclides in several ecological levels. Indicators are mangrove vegetation, fresh water algae, turtle grass and sponges. Additional items found in the human food chain that were analyzed include crustacea, fish, and food crops.

KEYWORDS: Air, crustacea, fish, food crops, Florida, preoperational survey, reactor, silt, soil, vegetation, water.

PREOPERATIONAL LEVELS OF ENVIRONMENTAL RADIOACTIVITY IN WATER AND SEDIMENT AROUND TURKEY POINT NUCLEAR POWER PLANTS, CARD SOUND, FLORIDA. *Tod S. Johnson and Thomas D. Pemble. Radiation Data and Reports, Vol. 15,* March 1974, pp. 116–123.

An investigation of the levels and distribution of gross alpha, gross beta and selected gamma-emitting radioisotopes present in water and sediment samples from Card Sound, Fla., was performed. This environmental radioactivity baseline study, was carried out between January 1971 and June 1972, prior to operation of the Turkey Point Nuclear Power Plants and discharge of liquid effluents from these plants into Card Sound.

KEYWORDS: Background radiation, Florida, reactor, sediment, water.

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